MORPHOLOGY AND PIGMENTATION OF CERTAIN YEASTS FROM BRINES AND THE CUCUMBER PLANT

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GENERAL INTRODUCTION [1, 2]

The purpose of this publication is to acquaint teachers, students, and research workers interested in the study of yeasts with some of our observations on the colonial and cellular morphology of the common yeast species associated with fermentations in brine.

The illustrative material shown, and hitherto unpublished, was compiled during the past several years in connection with our taxonomic studies on the principal species of yeasts associated with the gaseous fermentation of commercially brined cucumbers (*6*, *11*), as well as investigations on the identity of the types responsible for film formation on brines (*7*).

In addition to the above sources, material relating to recent work (unpublished) on the pigmented yeasts that occur on the cucumber plant has been included. Further, certain yeast species associated with meat brines are illustrated. The latter work represents a phase of investigations on meat microbiology being conducted in the Department of Animal Industry of the North Carolina Agricultural Experiment Station in cooperation with the Bureau of Animal Industry (USDA) Beltsville, Maryland.

The material presented is divided into three major parts: film-forming brine yeasts; subsurface brine yeasts; and, yeasts from the cucumber plant. Each is organized to permit ready comparison of the striking influence of cultural media on: colonial morphology; cellular morphology; film formation (for some species), and, in some instances, colonial pigmentation. In all, species and varieties of yeasts belonging to 12 genera are shown. It is our hope that the illustrative material will benefit other workers and serve to supplement the monographs, bulletins and articles on methods and classification we have found useful in our yeast work (*1*, *3*, *4*, *14*, *16*, *17*, *20*, *21*).

MEDIA AND METHODS

Because most of the cultural media used and techniques employed have been described in detail elsewhere, they will only be mentioned briefly here.

VEGETABLE-JUICE AGAR; as described by Wickerham *et al.* (*22*) and modified by Etchells and Bell (*6*). SYNTHETIC VEGETABLE-JUICE AGAR; a chemically defined medium designed to simulate vegetable-juice prepared for us by Dr. W. J. Peterson, Head, Department of Chemistry, North Carolina State College. GLUCOSE AGAR; as prepared by Etchells and Bell (*6*). GLUCOSE-SALT AGAR; as above but containing 8 percent salt by weight. SYNTHETIC AGAR-A; the glucose-mineral-salts medium used by Stelling-Dekker (*20*) plus 0.01 percent yeast extract. SYNTHETIC AGAR-B; prepared from Wickerham's (*21*) yeast nitrogen base medium as follows; heat sterilize in separate containers an equal amount of 3 percent agar, and an equal amount of double strength nitrogen base medium plus 4 percent glucose; then mix the contents of the two containers together before the agar cools and pour plates. SYNTHETIC BROTH-B; a heat sterilized, single strength, liquid form of the above medium (omit agar). Used for growing yeast cells in the tests for the presence and nature of carotenoid pigments. CORNMEAL AGAR; prepared according to Skinner *et al.* (*19*) and employed in the test for mycelium production by use of point inoculations as described by Wickerham and Rettger (*23*), and Wickerham (*21*). Salt-tolerance tests were made in the divided culture dishes of Etchells and Bell (*7*), using a liquid medium consisting of cucumber brine adjusted to cover a range from 5 to 20 percent salt by weight and fortified by the addition of glucose and ethyl alcohol in 1.0 percent amounts (*7*). Tests for growth in ethyl alcohol were made in regular culture dishes containing nutrient broth plus 3 percent ethyl alcohol as the carbon source. Stained cell preparations were made by the Kopeloff and Cohen modification of the Gram stain (*15*). Wet mount cell preparations were used to show living cells and spores from vegetable-juice agar cultures. Cells were suspended in erythrosin (1–10,000) buffered at pH 4.6, placed on a slide and the cover slip pressed down tightly and sealed with immersion oil.

[1] **The authors gratefully acknowledge the grant from the National Pickle Packers Association, Chicago, Illinois to the North Carolina Agricultural Experiment Station, that made this publication possible by underwriting the cost of reproducing the natural color and black and white photographs.**

[2] Paper No. 449 of the Journal Series of the North Carolina Agricultural Experiment Station.

FILM-FORMING BRINE YEASTS [3]

It has been mentioned in an earlier report (6) that yeasts associated with cucumber brines are divided into two general groups. Those that produce a gaseous fermentation in the brine and those that produce luxuriant, wrinkled films on the surface of brines exposed to air but sheltered from direct sunlight. It is not uncommon to find that the two groups are confused in the literature on cucumber pickling.

Film formation on 40 commercial cucumber brines obtained during 1947 and 1948 in five states (North Carolina, Georgia, Michigan, Indiana and Wisconsin) has been attributed to species of *Debaryomyces*, *Zygosaccharomyces*, *Endomycopsis*, and *Candida* (7). The predominating species found were *D. membranaefaciens* var. *Hollandicus*, and *Z. halomembranis*. They were also the most salt-tolerant. Yeasts belonging to the genus *Debaryomyces* were the most widespread and were found on brines in all five states.

A similar study was done in 1950 on the film yeasts from 23 commercial brines in Indiana, Michigan and Wisconsin (*10*). Emphasis here was placed on brines less than two months old and with salt concentrations of about 10 percent. The two predominating yeasts found were the same as obtained in the earlier study. However, the presence of cultures of *Pichia alcoholophila* and *Hansenula anomala* appeared to be related to the lower salt-content of the brines.

Salt-tolerance tests have since shown that the above two yeasts grew poorly if at all above 10 percent. The same is true for *Candida krusei* obtained from low salt-content dill pickle brines in the 1947–48 study.

In addition to brined cucumbers, film-forming yeasts are found in connection with a number of other similarly preserved foods. For example, Mrak and Bonar (*18*) investigated 28 cultures isolated from surface films on 27 samples of various brined foods (dill pickles, salt-stock pickles, Zucca melon, green olives, Sicilian olives, dill weed, cauliflower, and ham brine). They found film yeasts that belonged to three genera: *Debaryomyces*, 16 cultures; *Pichia*, 9; and *Mycoderma*, 3. The *Debaryomyces* species were the most widely distributed in the brines. They were also found to be the most salt-tolerant (up to 24%).

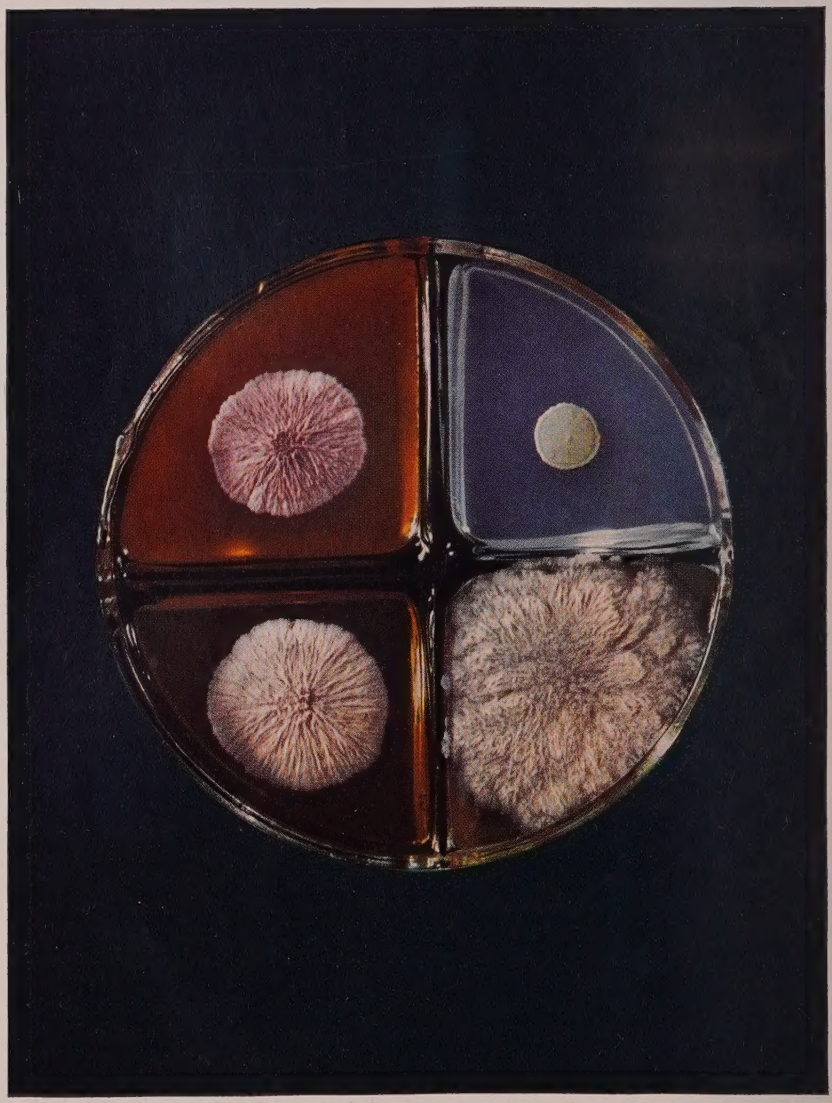
Etchells and Costilow (*9*) investigated the nature of film-forming yeasts on commercial meat brines (bacon sides, hams, beef tongues and Canadian bacon). A total of 89 yeast isolates was obtained and all were identified as belonging to the genus *Debaryomyces*. Eighty-six cultures were placed as *D. membranaefaciens* var. *Hollandicus*. The remaining three cultures were non-film-forming species that came from subsurface brine samples; these were classified as being closely related to *D. klockeri*. This yeast was also found to be the predominating type found in subsurface samples from bacon brines during a prolonged curing period.

More recently, Zenitani (*24*), isolated 29 yeast cultures from a Japanese fishery-fermentation product known as "Shiokara." Generic placement of the cultures was a follows: *Debaryomyces*, 19; *Zygosaccharomyces*, 8; *Hansenula* and *Torulaspora*, 1 each.

It is apparent that film-forming species of *Debaryomyces* are the most widely distributed yeasts associated with food brines. Other species in the approximate order of their importance would be; *Zygosaccharomyces halomembranis*, *Endomycopsis ohmeri* (and variety *minor*), *Candida krusei*, *Hansenula anomala* and *Pichia alcoholophila*.

[3] Since this article was prepared, the important new book, "The Yeasts — A Taxonomic Study," by the Dutch workers, J. Lodder and N. J. W. Kreger-Van Rij, has appeared. Thus, we have not had an opportunity to consider their proposed changes in yeast classification.

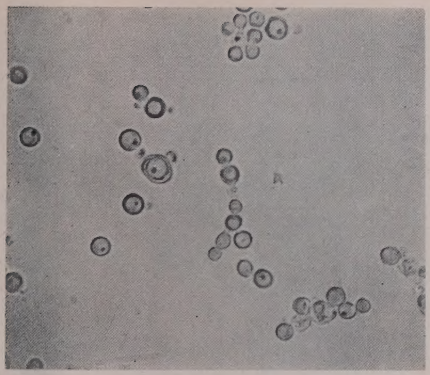
Debaryomyces



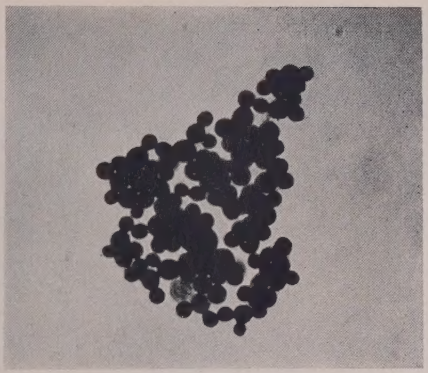
Vegetable-juice agar
Glucose agar

Synthetic agar-A
Glucose-salt agar

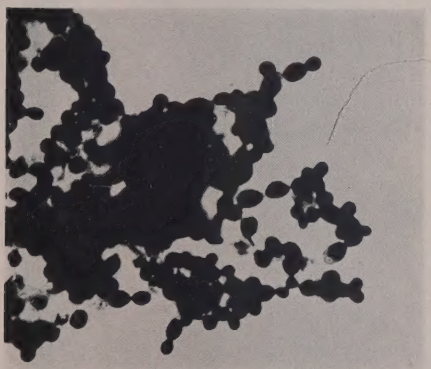
A. Comparative growth by *Debaryomyces membranaefaciens* var. *Hollandicus* Lodder (FY-36, Georgia strain) on different cultural media after 6 weeks' incubation at room temperature. Actual size. SEE OPPOSITE PAGE FOR CELLS AND GROWTH TESTS OF THIS YEAST.



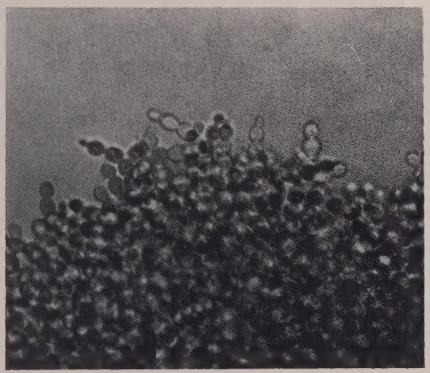
1. Sporulated cells from vegetable-juice agar at 2 months. Note rough spore (upper left); others completely fill asci. Unstained, × 1500.



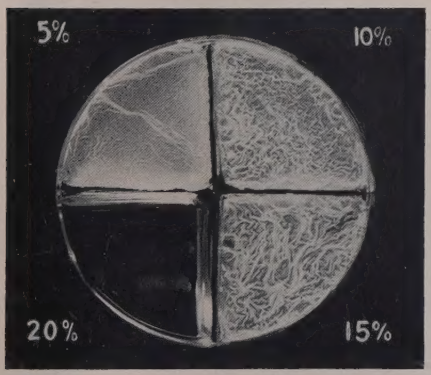
2. Round to oval cells from synthetic agar-A, 7-day old culture. Gram stained, × 1500.



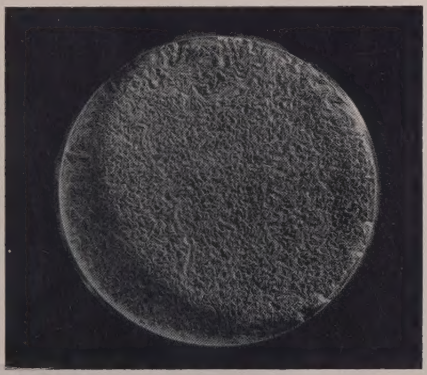
3. Cells from film on 10% salt cucumber brine, 5 days old. Gram stained, × 1500.



4. These cells show negative mycelium test on cornmeal agar at 3 weeks. Unstained, × 650; enlarged, × 2.

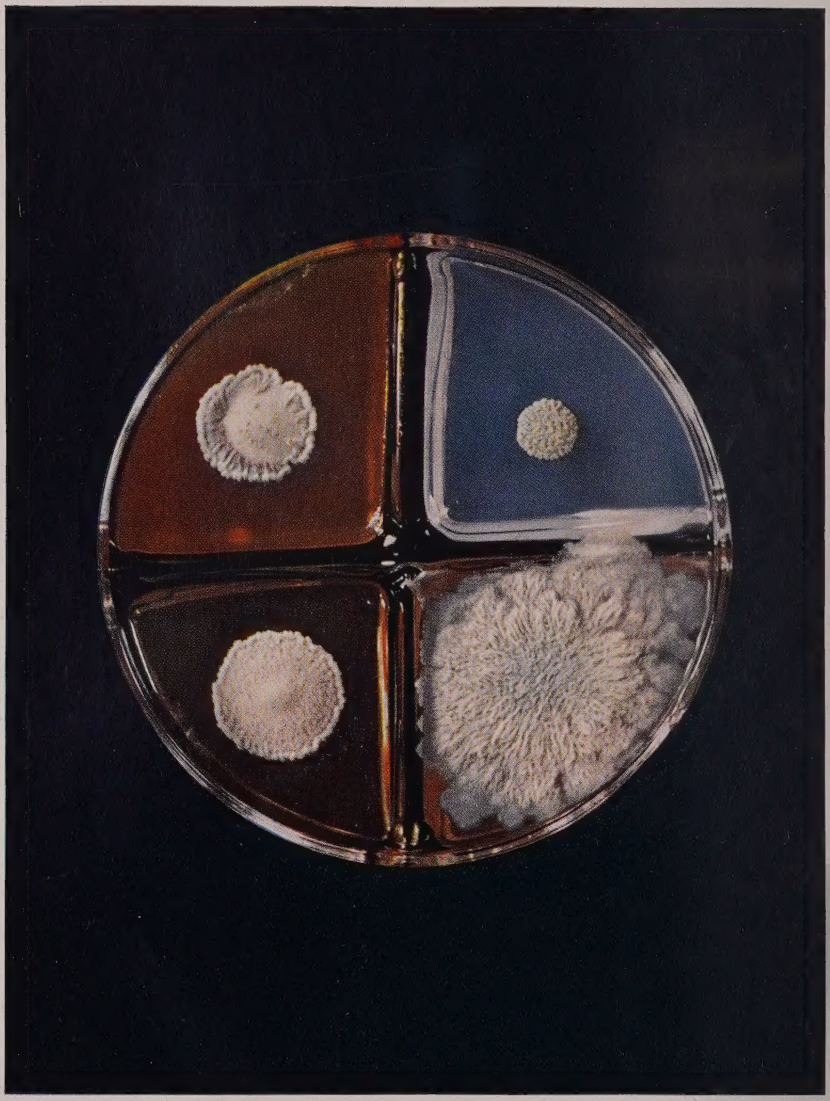


5. Salt-tolerance test at 7 days shows good growth at 3 brine concentrations; 10 days required for heavy growth at 20%. × ½.



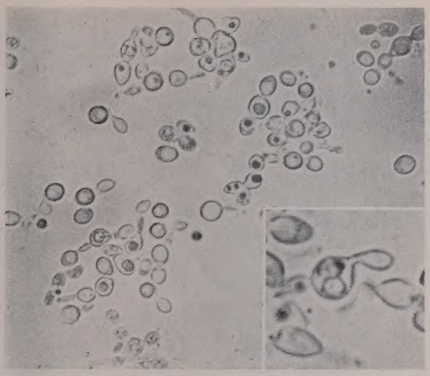
6. Heavy film formation on ethyl alcohol medium at 4 days. × ½.

Debaryomyces

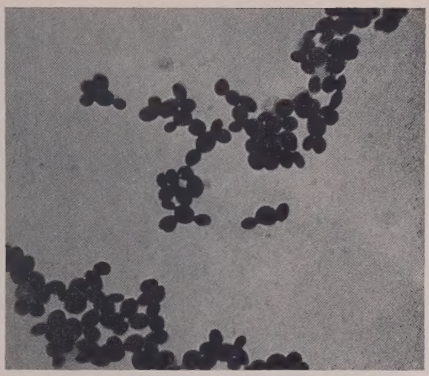


Vegetable-juice agar
Glucose agar
Synthetic agar-A
Glucose-salt agar

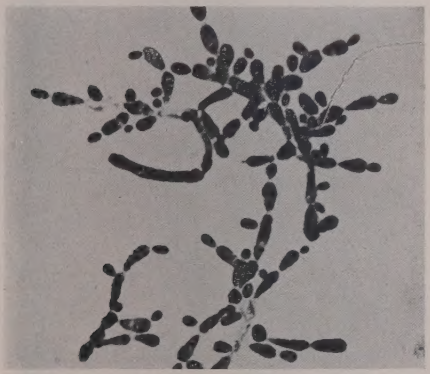
B. Comparative growth by *Debaryomyces membranaefaciens* var. *Hollandicus* Lodder (NFY-20, Wisconsin strain) on different cultural media after 6 weeks' incubation at room temperature. Actual size. SEE OPPOSITE PAGE FOR CELLS AND GROWTH TESTS OF THIS YEAST.



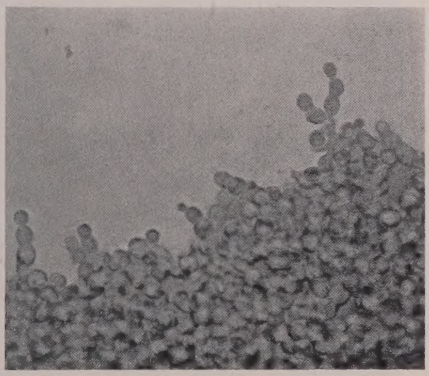
7. Tubular cells and single spores from vegetable-juice agar at 2 months. Unstained, × 1500. Insert; ascus with 2 spores, enlarged, × 2.



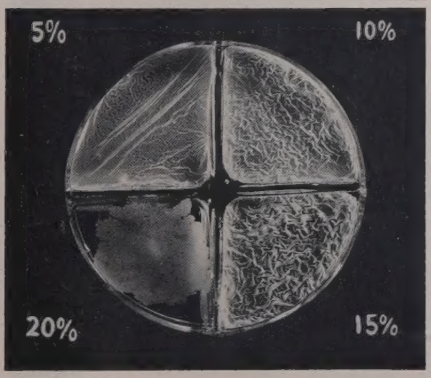
8. Round to oval cells from synthetic agar-A after 7 days. Gram stained, × 1500.



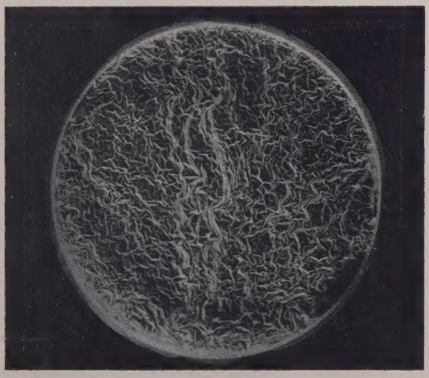
9. Elongated cells from film on 10% salt cucumber brine, 48 hours. Gram stained, × 1500.



10. Cells from cornmeal agar show negative mycelium test at 3 weeks. Unstained, × 950; enlarged, × 2.

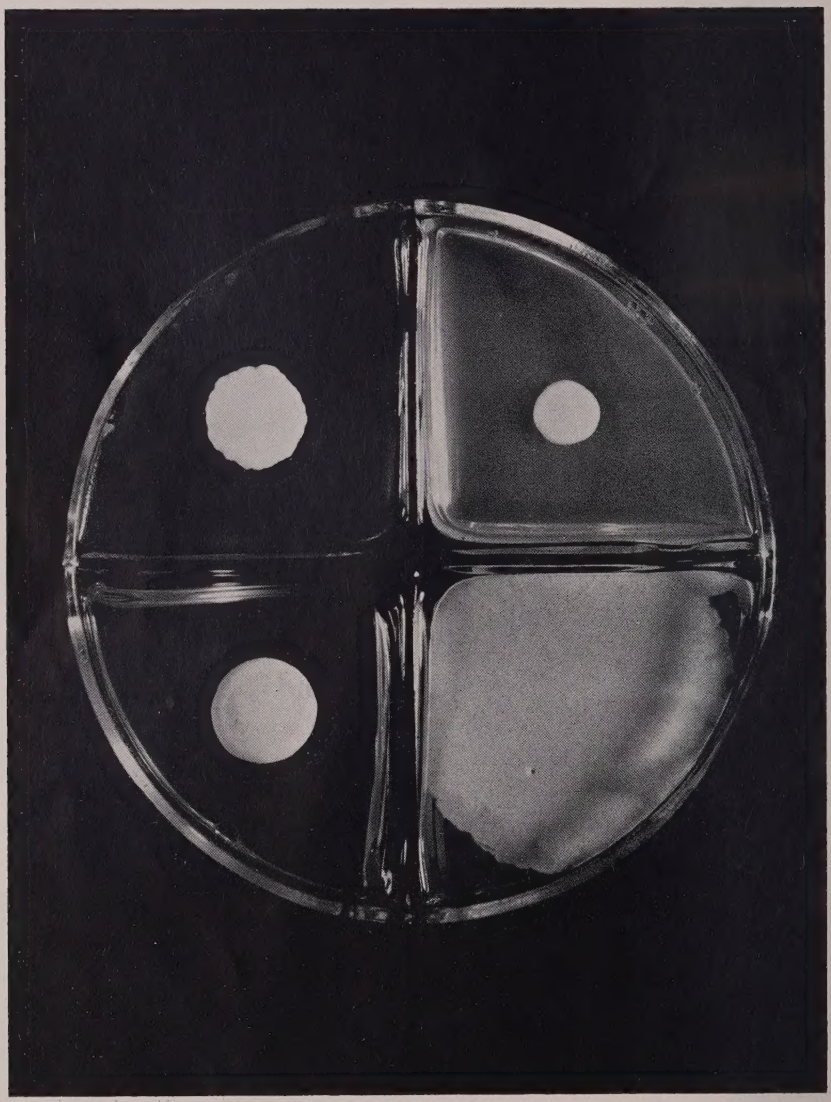


11. Salt-tolerance test at 12 days with films at all 4 brine strengths. × ½.



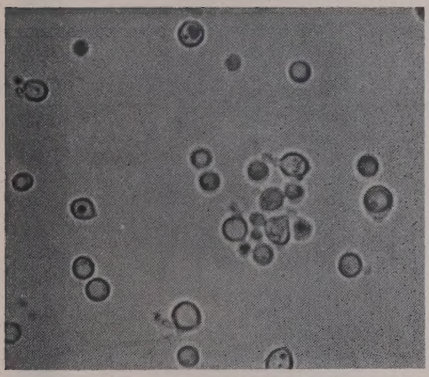
12. Heavy film formation on ethyl alcohol medium at 4 days. × ½.

Debaryomyces

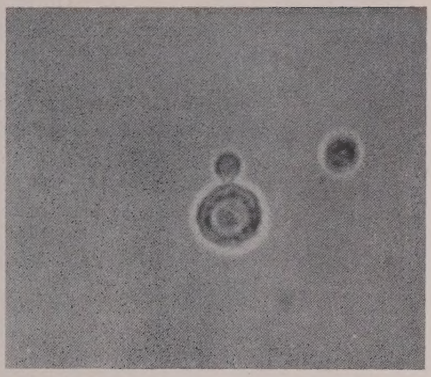


Vegetable-juice agar
Glucose agar
Synthetic agar-A
Glucose-salt agar

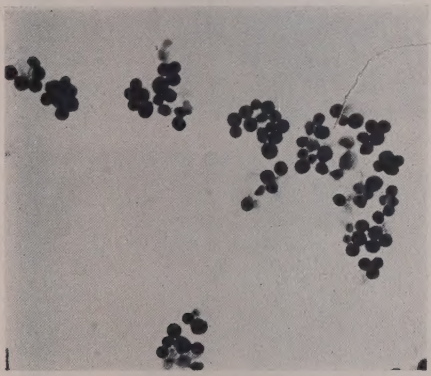
13. Comparative growth by a smooth species of *Debaryomyces* (FY-34) on different cultural media after 6 weeks' incubation at room temperature. Slightly enlarged. SEE OPPOSITE PAGE FOR CELLS AND GROWTH TESTS OF THIS YEAST.



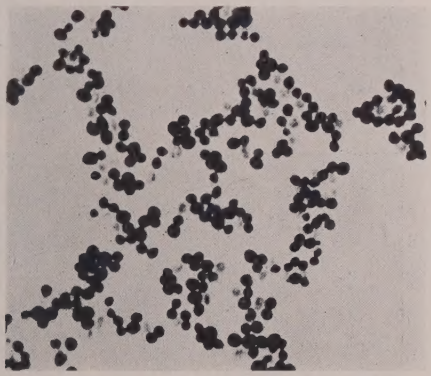
14. Round cells from vegetable-juice agar at 2 months; ascus filled with single spore at right center. Unstained, × 1500.



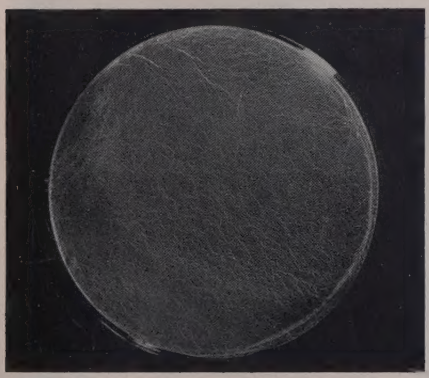
15. Typical ascus with rough spore and centrally located oil drop. From vegetable-juice agar at 2 months. Unstained, × 1500; enlarged, × 2.



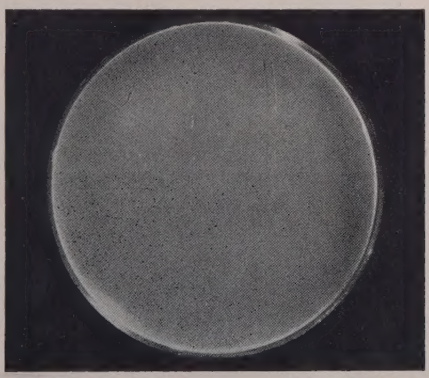
16. Cells from synthetic agar-A after 7 days. Gram stained, × 1500.



17. Cells from film on 10% salt cucumber brine after 5 days. Gram stained, × 1500.

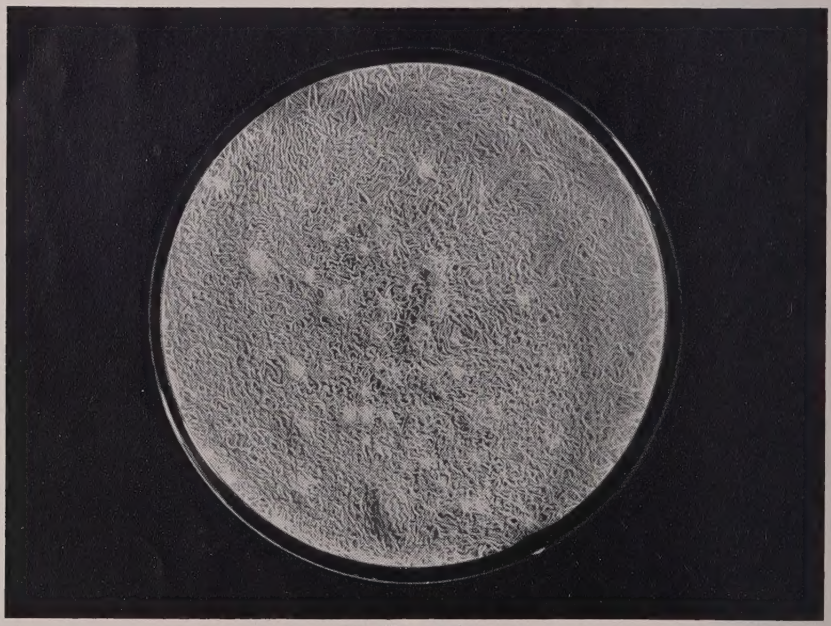


18. Film formation at 3 days on 7% salt cucumber brine. × ½.



19. This yeast forms a very thin film on ethyl alcohol medium. × ½.

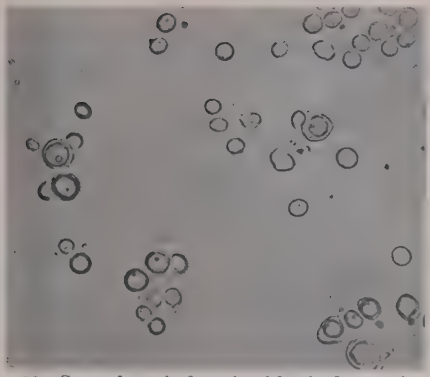
20. Beef tongue brine



21. Ham brine

Naturally occurring films on commercial curing brines from beef tongues (above) and hams (below) after 7 days' incubation at room temperature. Slightly reduced in size. The principal yeast species responsible for these films is the Georgia strain of *D. membranaefaciens* var. *Hollandicus* (shown on pages 268, 269). SEE OPPOSITE PAGE FOR CELLS AND GROWTH TESTS OF SUBSURFACE SPECIES OF *DEBARYOMYCES* FROM BRINED BACON SIDES.

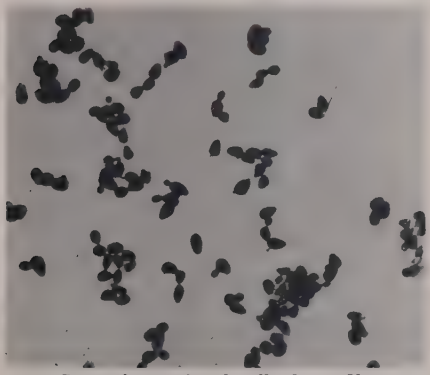
DEBARYOMYCES SP. (Y-6-BA)



22. Several typical asci with single rough spores; from vegetable-juice agar at 2 months. Unstained, × 1500.

23. Absence of film or subsurface growth in ethyl alcohol medium at 3 days is typical of this species. × ½.

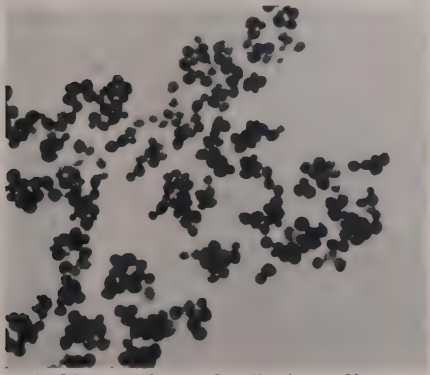
DEBARYOMYCES SP. (Y-37-BA)



24. Somewhat pointed cells from film on 5% salt cucumber brine after 48 hours. Gram stained, × 1500.

25. Very thin climbing scum is formed by this yeast on ethyl alcohol medium at 3 days. × ½.

DEBARYOMYCES SP. (Y-40-BA)



26. Masses of round cells from film on 5% salt cucumber brine after 48 hours. Gram stained, × 1500.

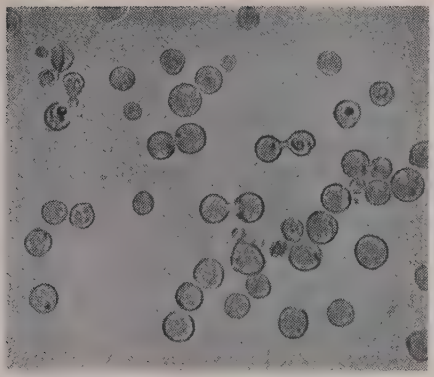
27. Thin film formation on ethyl alcohol medium at 3 days is typical of this species. × ½.

Zygosaccharomyces

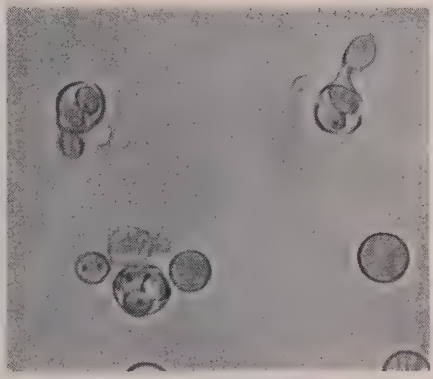
Vegetable-juice agar
Synthetic agar-A

Glucose agar

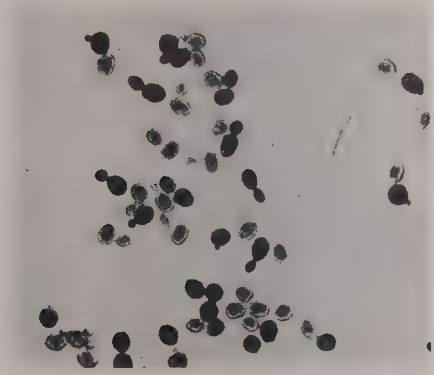
28. Comparative growth by *Zygosaccharomyces halomembranis* Etchells & Bell (Y-1000) on different cultural media after 6 weeks' incubation at room temperature. Colonies enlarged, × 3. In cucumber brines from Michigan, Wisconsin and Indiana, this species occurs both as a surface and subsurface yeast. SEE OPPOSITE PAGE FOR CELLS AND GROWTH TESTS OF THIS YEAST.



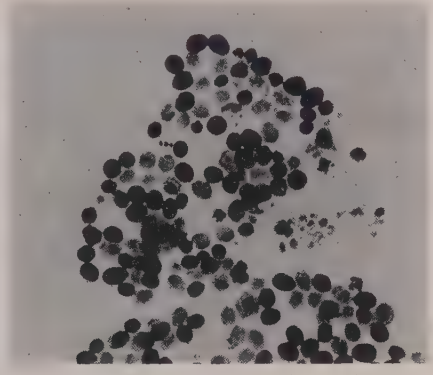
29. Early stage of sporulation, with conjugated round cells; from vegetable-juice agar at 3 weeks. Unstained, × 1500.



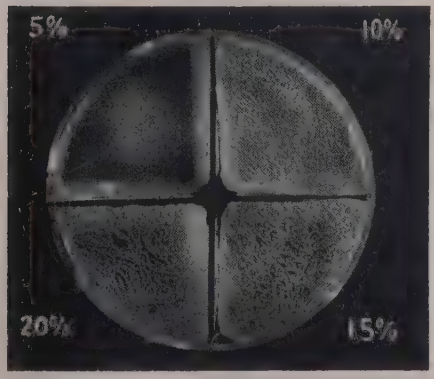
30. Fully developed asci with 2 and 3 oval spores each; from vegetable-juice agar at 1 month. Unstained, × 1500; enlarged, × 2.



31. Young cells, 48 hours old, from film on 10% salt cucumber brine. Gram stained, × 1500.



32. Masses of older cells, 5 days old, from film on 10% salt cucumber brine. Gram stained, × 1500.



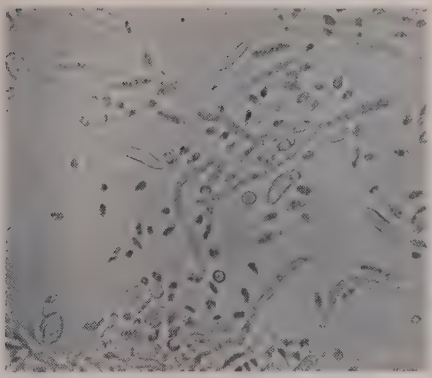
33. Salt-tolerance test at 5 days shows heavy film formation at all 4 salt concentrations. × ½.

34 Subsurface growth but no film formation on ethyl alcohol medium is typical for this species. × ½.

Endomycopsis

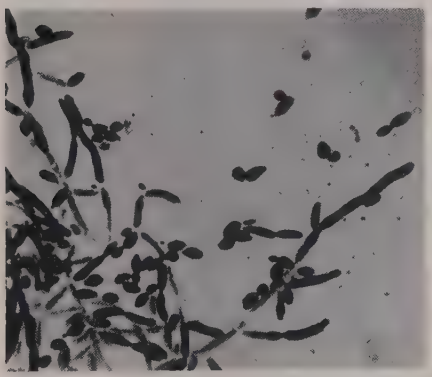
Vegetable-juice agar | Synthetic agar-A
Glucose agar | Glucose-salt agar

C. Comparative growth by *Endomycopsis ohmeri* Etchells & Bell (FY-25) on different cultural media after 6 weeks' incubation at room temperature. Actual size. So far this species has only been isolated from North Carolina brines. SEE OPPOSITE PAGE FOR CELLS AND GROWTH TESTS OF THIS YEAST.

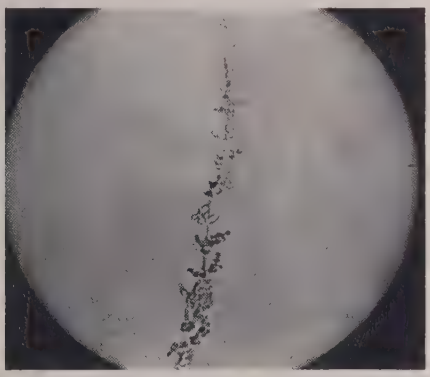


35. Pleomorphic cells from vegetable-juice agar after 4 months. No spores present. Unstained, × 1500.

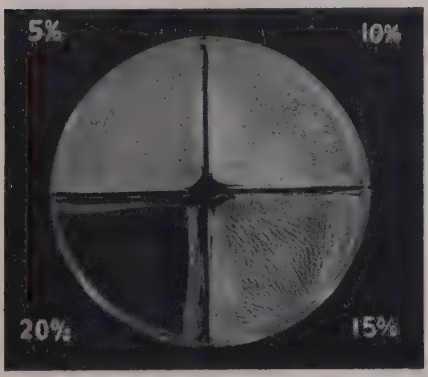
36. Typical cells from synthetic agar-A after 7 days. Gram stained, × 1500.



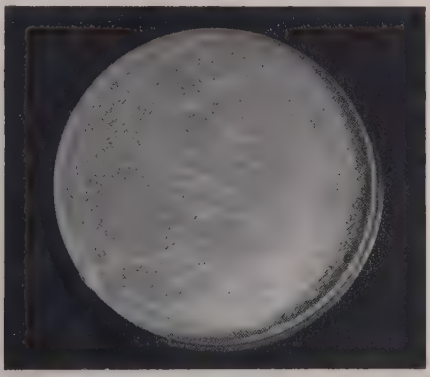
37. Elongated cells from film on 10% salt brine after 48 hours. Gram stained, × 1500.



38. Single, long mycelial thread with clusters of cells; from cornmeal agar after 3 weeks. Unstained, × 650.

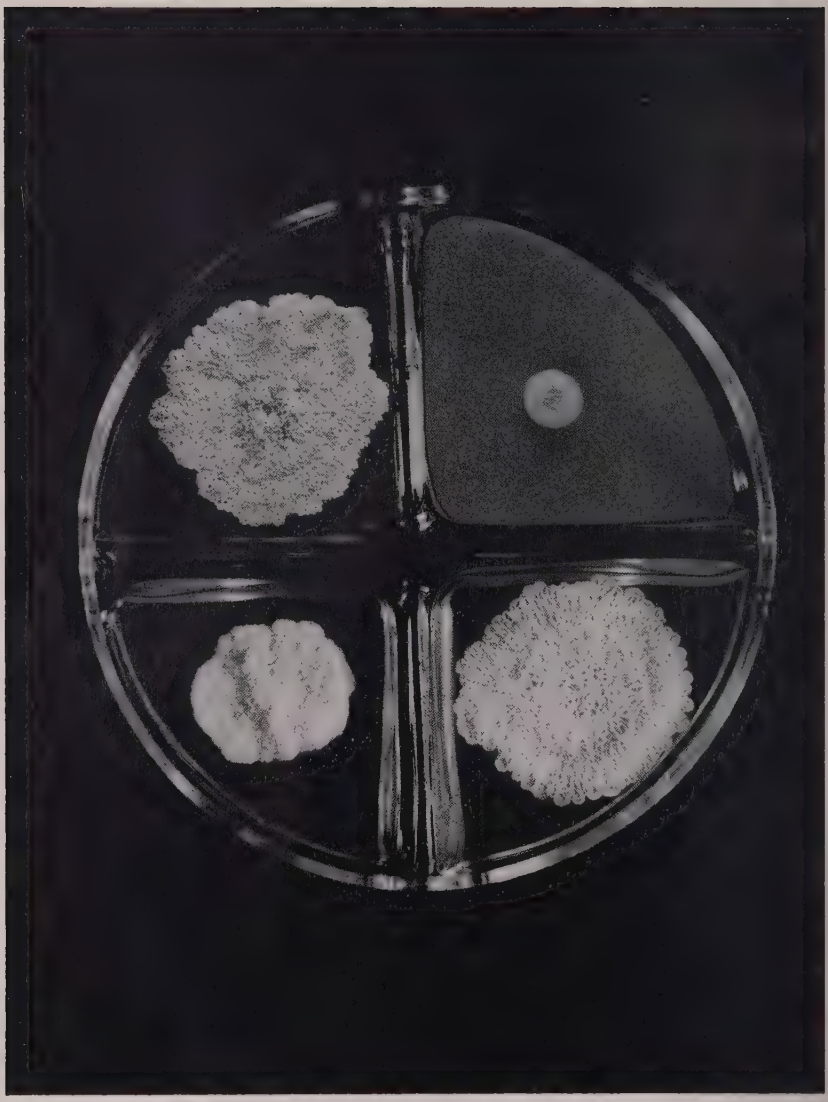


39. Salt-tolerance test shows film growth on 15% brine but not 20% at 5 days. Films disintegrate quickly at 5 and 10%. × ½.



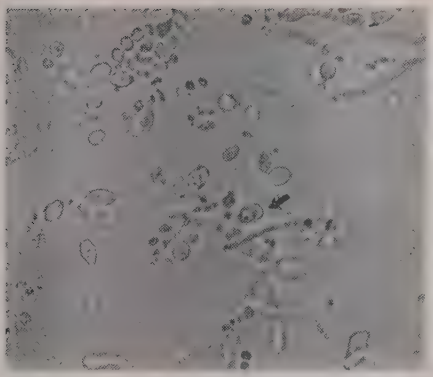
40. Good film growth occurs in 4 days on ethyl alcohol medium. × ½.

Endomycopsis



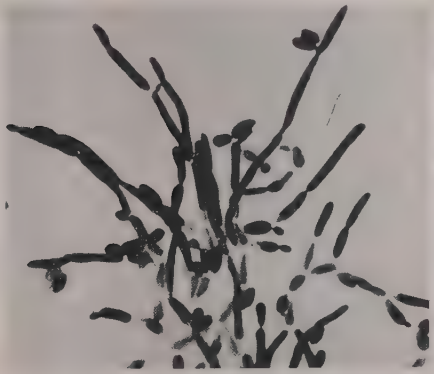
Vegetable-juice agar
Glucose agar
Synthetic agar-A
Glucose-salt agar

41. Comparative growth by *Endomycopsis ohmeri* var. *minor* Etchells & Bell (FY-1) on different cultural media after 6 weeks' incubation at room temperature. Slightly enlarged. SEE OPPOSITE PAGE FOR CELLS AND GROWTH TESTS OF THIS YEAST.

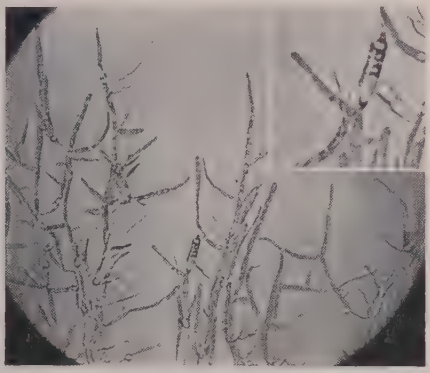


42. Pleomorphic cells from vegetable-juice agar after 4 months. Single spore in ascus (arrow). Unstained, × 1500.

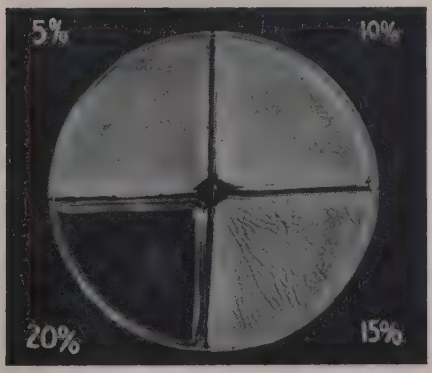
43. Cells from synthetic agar-A after 7 days. Gram stained, × 1500.



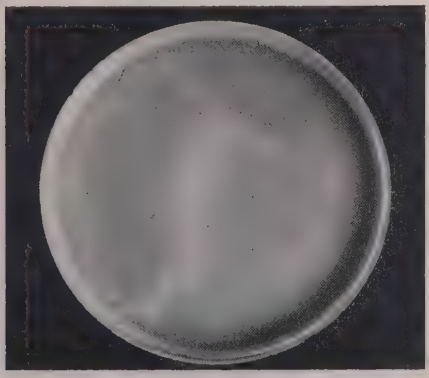
44. Elongated cells from film on 10% salt brine after 48 hours. Gram stained, × 1500.



45. Mycelium formation on cornmeal agar after 3 weeks; unstained, × 650. Insert, 2 spores from mycelium, enlarged, × 2.



46. Salt-tolerance test shows film growth on 15% brine but not 20% at 5 days. Films on 5 and 10% have fallen. × ½.

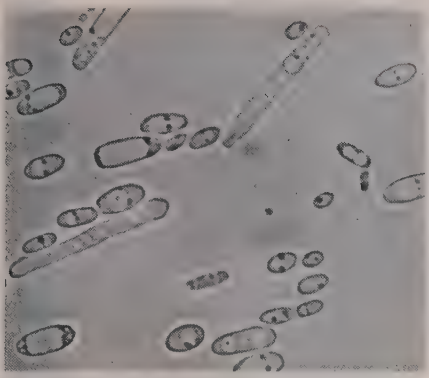


47. A smooth, membrane-type film forms on ethyl alcohol medium in 4 days. × ½.

Candida

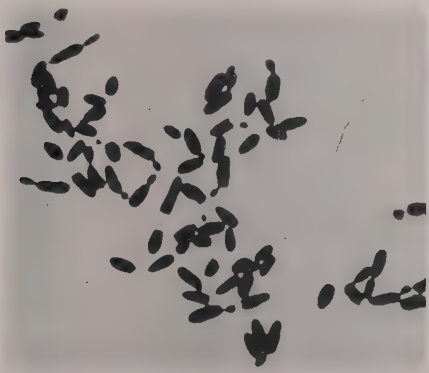
Vegetable-juice agar
Glucose agar
Synthetic agar-A
Glucose-salt agar

D. Comparative growth by *Candida krusei* (A. Cast.) Berkhout (FY-20) on different cultural media after 6 weeks' incubation at room temperature. Actual size. SEE OPPOSITE PAGE FOR CELLS AND GROWTH TESTS OF THIS YEAST.

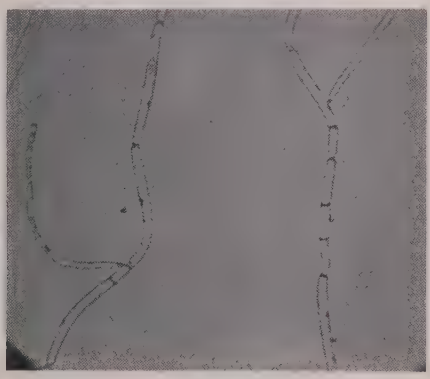


48. Typical cells from vegetable-juice agar at 3 weeks. Unstained, × 1500.

49. Cells from synthetic agar-A after 7 days. Gram stained, × 1500.

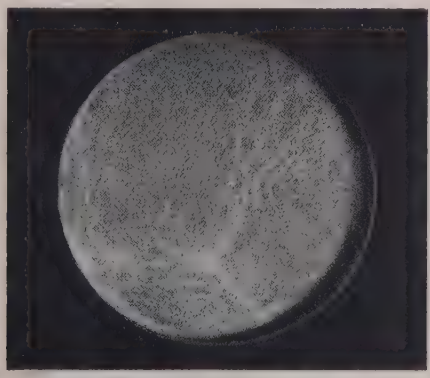


50. Cells from film on 10% salt brine after 5 days. Gram stained, × 1500.



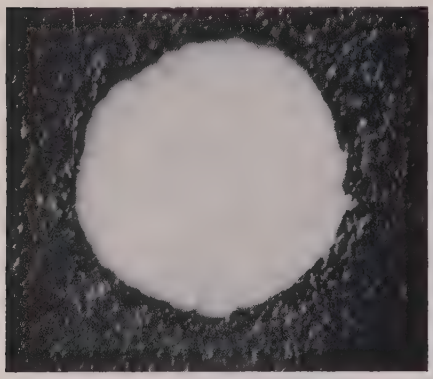
51. Evidence of septated mycelium on cornmeal agar after 3 weeks. Unstained, × 650; enlarged, × 2.

52. Salt-tolerance test shows no film growth above 10% brine strength after 7 days. × ½.

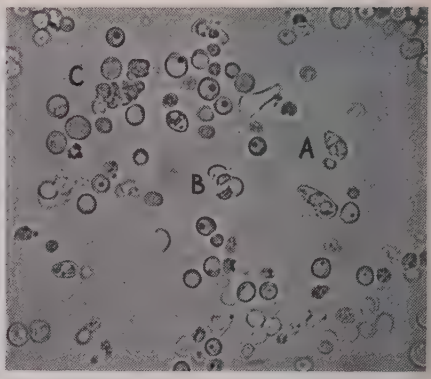


53. Heavy film formation on ethyl alcohol medium at 4 days. × ½.

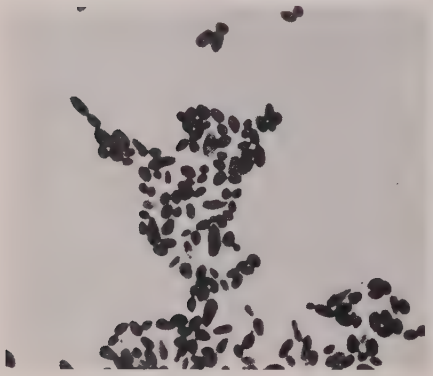
HANSENULA ANOMALA (HANSEN) SYDOW (KS)



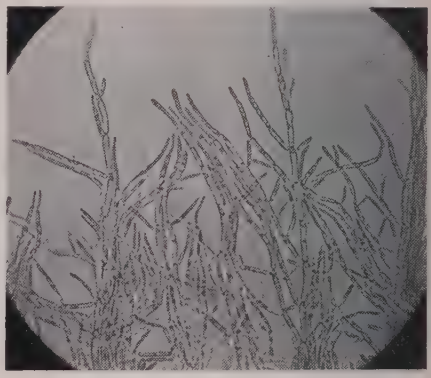
54. Giant colony grown on vegetable-juice agar, 6 weeks. × 2.



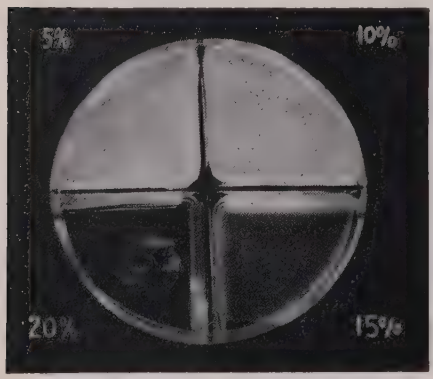
55. Sporulation at 2 months. *A*, hat-shaped spores in ascus; *B*, emerging spore; *C*, cluster of free spores. Unstained, × 1500.



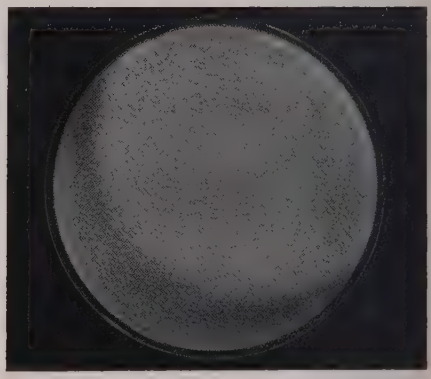
56. Cells from film on 5% salt brine after 48 hours. Gram stained, × 1500.



57. Mycelium formation on cornmeal agar after 3 weeks. Unstained, × 650.

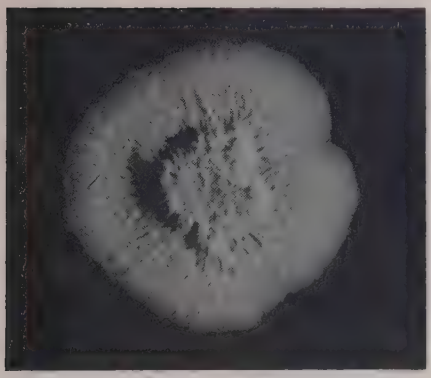


58. Salt-tolerance test shows heavy films at 5 and 10% brines, a very thin film on 15%, after 7 days. × ½.

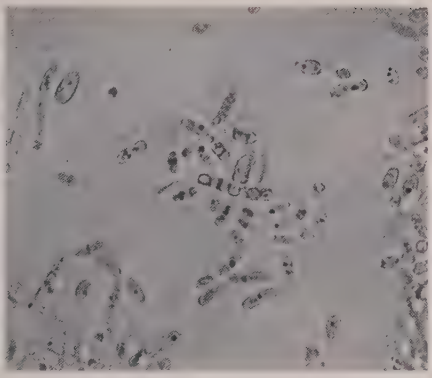


59. Heavy film formation on ethyl alcohol medium at 4 days. × ½.

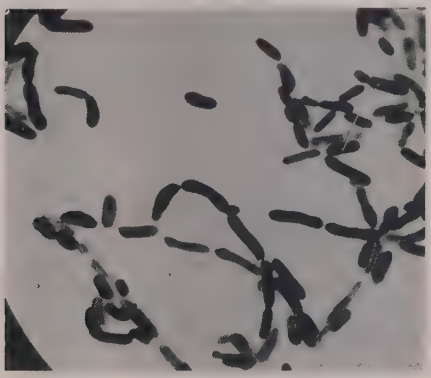
PICHIA ALCOHOLOPHILA KLOCKER (FY–31)



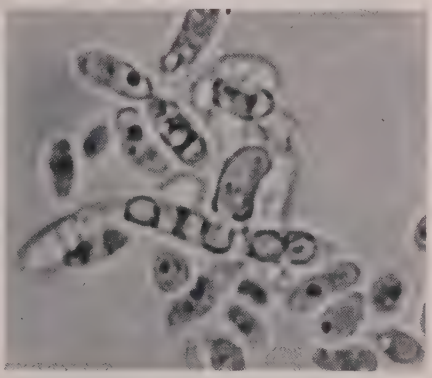
60. Giant colony grown on vegetable-juice agar; at 6 weeks. × 2.



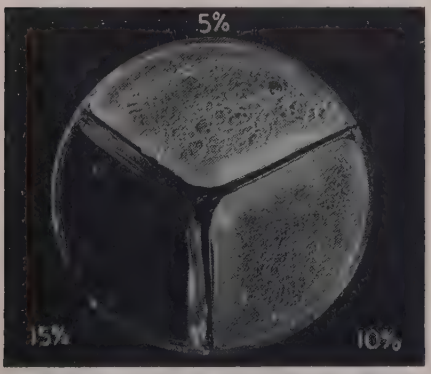
61. Sporulation on vegetable-juice agar at 2 months. Unstained, × 1500.



62. Sausage-shaped cells from film on 5% saltbrine after 48 hours. Gram stained, × 1500.



63. Enlarged section of above; fully developed asci with 2 and 4 helmet-shaped spores.



64. Salt-tolerance test shows film growth at 5 and 10% brines; no growth at 15% after 3 days. × ½.

65. Heavy film formation on ethyl alcohol medium at 4 days. × ½.

SUBSURFACE BRINE YEASTS

Active growth by the fermentative subsurface yeasts in commercial cucumber brines was first reported in 1941 *(5)*. Since then, their growth activity has been reported in a variety of other brined and salted vegetables *(12)*. In contrast to film-forming types, the growth of subsurface species in brines is characterized by a gaseous fermentation which results in the evolution of rather large amounts of carbon dioxide.

Further, their growth covers a wide range with respect to brine concentration, the maximum salt-tolerance observed under commercial conditions being in the neighborhood of 20 to 22 percent by weight (saturation being 26.4). Usually, the salt content of the brine determines the time yeast growth starts as well as the duration of activity.

As a rule, fermentations in low salt content brines (about 5 percent) start earlier and are of shorter duration than those at higher concentrations (10 to 15 percent). The reason for more active yeast development in the stronger brines is that the lactic acid bacteria are inhibited as the brine strength increases and more food material remains for the yeasts which are much more salt-tolerant.

Studies on commercially brined cucumbers represent the principal source of information on the identity and sequence of individual yeast species in brine-fermented foods. Basic investigations of this type have been reported in detail *(6, 11)* for the two major cucumber brining areas in the country — northern and southern. A brief summary of these two studies, based on the identity of nearly 1,900 cultures, demonstrates that the pattern for the principal yeast species in brines from both areas is very similar. Seven of the nine species found were obtained from both northern and southern brines *(i.e. Brettanomyces versatilis, Torulopsis caroliniana, Torulopsis holmii, Torulaspora rosei, Hansenula subpelliculosa, Zygosaccharomyces halomembranis* and *Zygosaccharomyces globiformis)*. The presence of *Saccharomyces globosus* in northern brines was considered to be the principal floral difference.

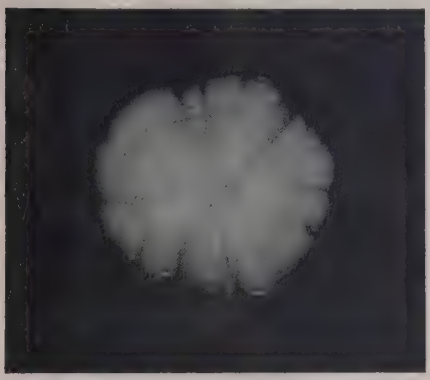
Because a gaseous fermentation by subsurface yeasts is associated with a type of spoilage known as "bloater" or hollow cucumber formation, yeast growth is of economic importance to the pickling industry. "Bloating" can be either in the form of lens-shaped gas pockets in the tissue, or the gas pressure can be sufficient to press the whole seed portion of the cucumber toward the skin, thus leaving a large gas-filled cavity.

Yeasts are also responsible for certain types of spoilage in manufactured pickle products. This is particularly true in cases of non-pasteurized products where the vinegar and sugar concentrations are insufficient to inhibit their growth, or, where they are allowed to develop high tolerance to vinegar and sugar through lack of plant sanitation. In a recent outbreak of spoilage of sweet pickles a number of very acid- and sugar-tolerant yeast cultures were obtained and identified as *Zygosaccharomyces globiformis* (*2*). It is recalled that this yeast was found in cucumber fermentations located in the principal brining areas of the country.

So far, the brine yeast species studied have not been incriminated as a potential source of the cucumber salt-stock softening enzyme pectinase *(8)*. However, a strain of *S. cerevisiae* isolated from soft dill pickles (YD-15, page 293) appears to be identical taxonomically with strains isolated from spoiled citrus concentrate (*13*) that do produce this enzyme (D-6, page 293).

Torulopsis

T. CAROLINIANA ETCHELLS & BELL (RY–165)

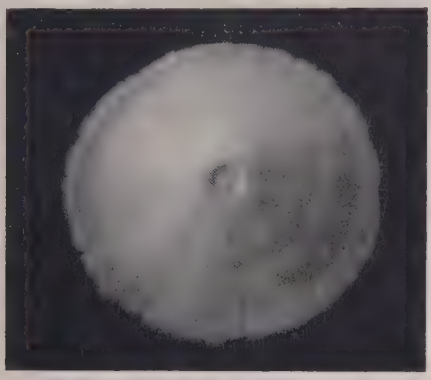


66. Giant colony grown on vegetable-juice agar; at 6 weeks. × 3.

67. Cells from vegetable-juice agar at 1 month. These cells are among the smallest of known yeasts. Gram stained, × 1500.

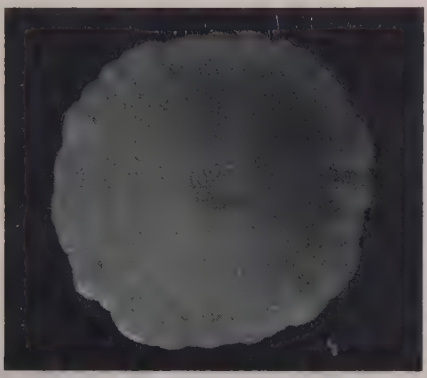
68. Giant colony grown on synthetic agar-A; at 6 weeks. × 4.

T. HOLMII (JORGENSEN) LODDER (Y–600)



69. Giant colony grown on vegetable-juice agar; at 6 weeks. × 2.

70. Cells from cornmeal agar are short-oval with no tendency to elongate. Unstained, × 950; enlarged, × 2.



71. Giant colony grown on synthetic agar-A; at 6 weeks. × 3.

Glucose agar Vegetable-juice agar Synthetic agar-A

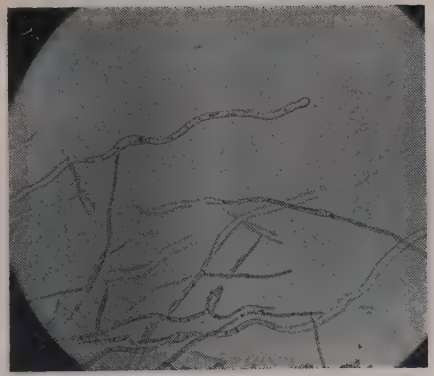
E. Comparative growth of 5 species of *Brettanomyces* on 3 cultural media after 6 weeks' incubation at room temperature. About ⅔ actual size.

↑

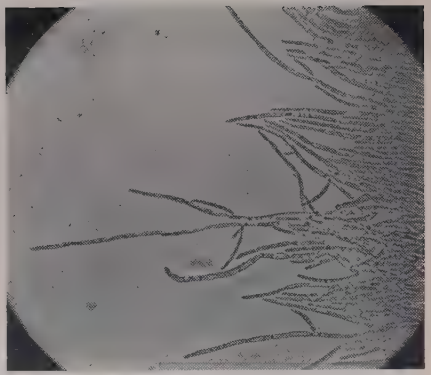
B. bruxellensis

B. lambicus *B. versatilis* *B. claussenii*

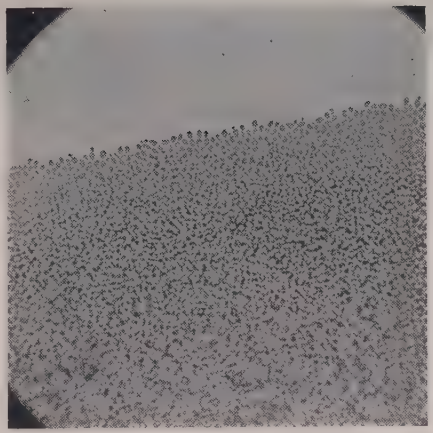
B. anomalus



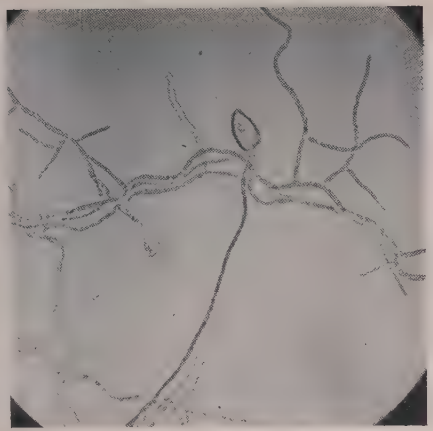
75. *B. lambicus*



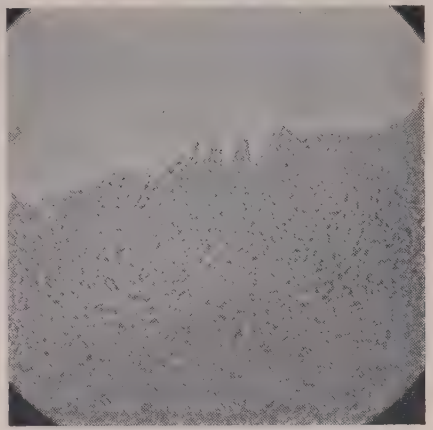
72. *B. bruxellensis*



74. *B. versatilis*



76. *B. anomalus*

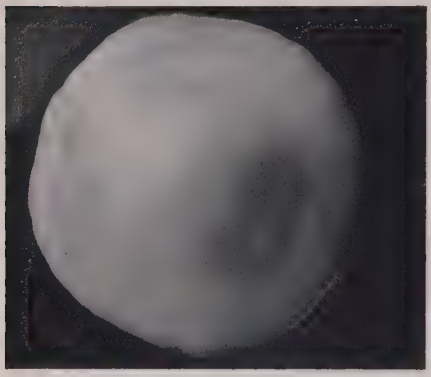


73. *B. claussenii*

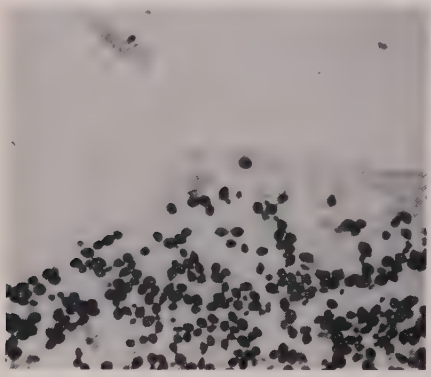
Cornmeal agar mycelium tests at 3 weeks for five species of *Brettanomyces*. *B. versatilis* and *B. claussenii* show normal cells; other 3 species produce mycelium. Unstained, × 950.

Brettanomyces

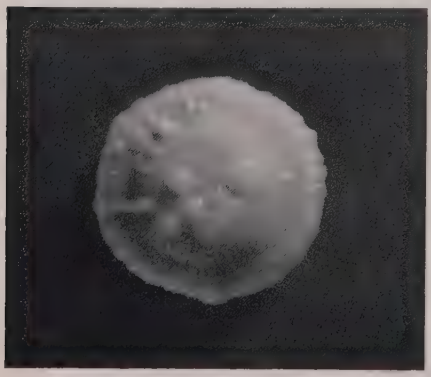
B. VERSATILIS ETCHELLS & BELL (Y–1016)



77. Giant colony grown on vegetable-juice agar; at 6 weeks. × 3.



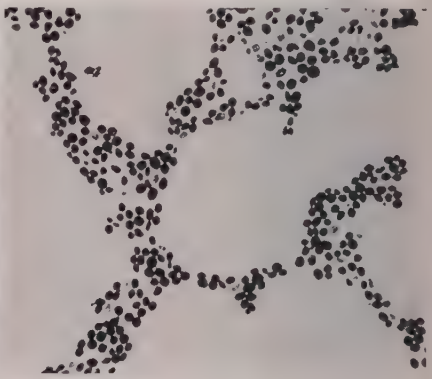
78. Cells from vegetable-juice agar at 1 month. Note pointedness of some cells. Gram stained, × 1500.



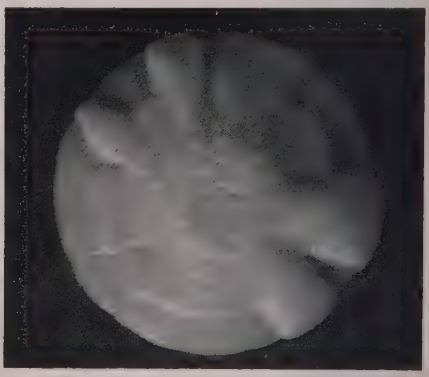
79. Giant colony grown on synthetic agar-A; at 6 weeks. × 4.

B. SPHAERICUS ETCHELLS & BELL (YS–606)

80. Giant colony grown on vegetable-juice agar; at 6 weeks. × 2.



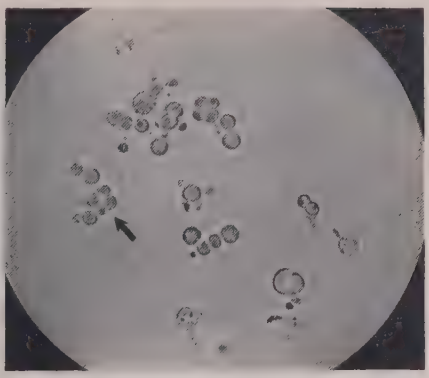
81. Cells from vegetable-juice agar at 1 month. Gram stained, × 1500.



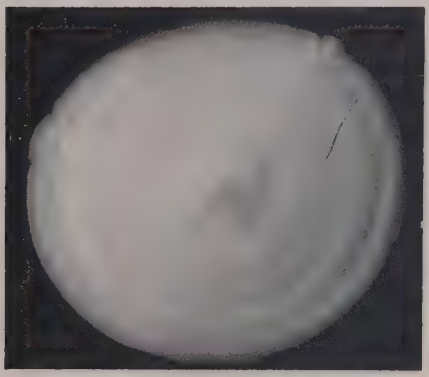
82. Giant colony grown on synthetic agar-A; at 6 weeks. × 4.

T. ROSEI LINDNER (RY-20)

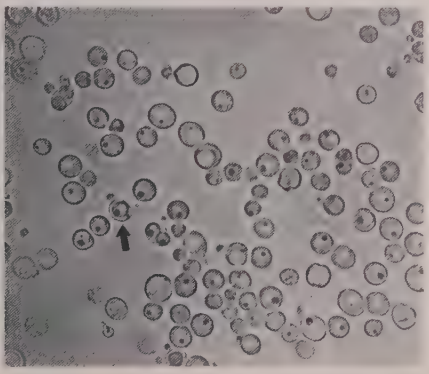
83. Giant colony grown on vegetable-juice agar; at 6 weeks. × 2.



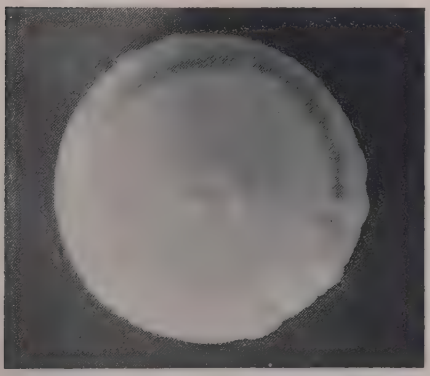
84. Sporulation on vegetable-juice agar at 1 month with 1, 2, and 4 (at arrow) round spores per ascus. Unstained, × 1500.



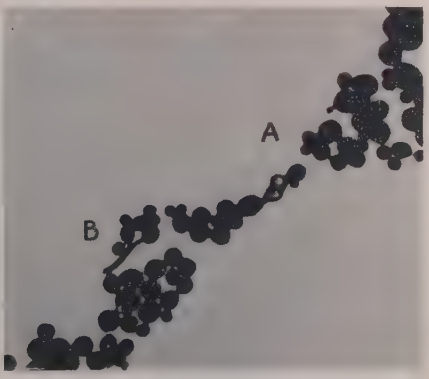
85. Giant colony grown on glucose agar; at 6 weeks. × 2.



86. Cells from a strain difficult to sporulate. Note single round spore at arrow. Grown on vegetable-juice agar; at 3 weeks. Unstained, × 1500.



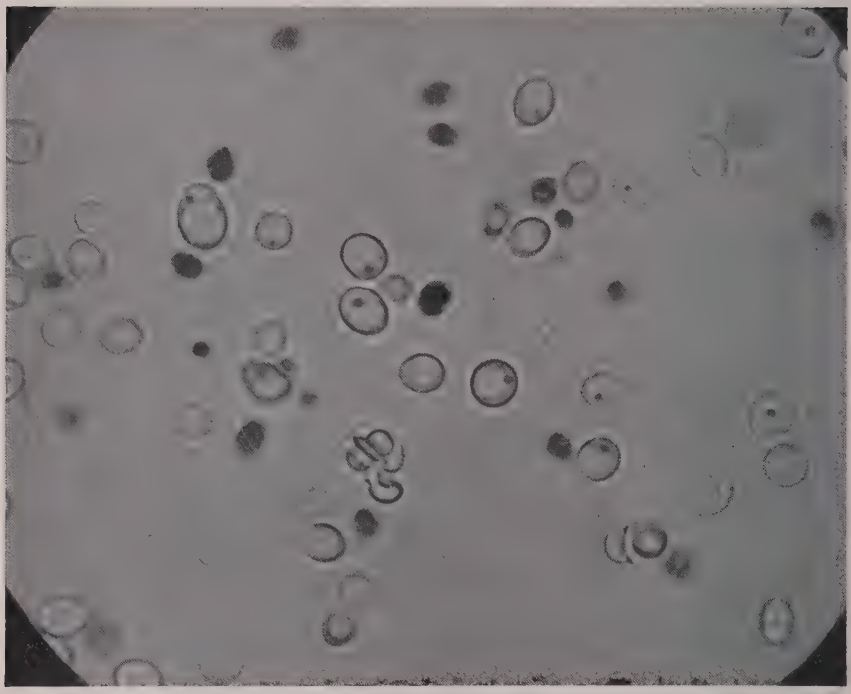
87. Giant colony grown on synthetic agar-A; at 6 weeks. × 3.



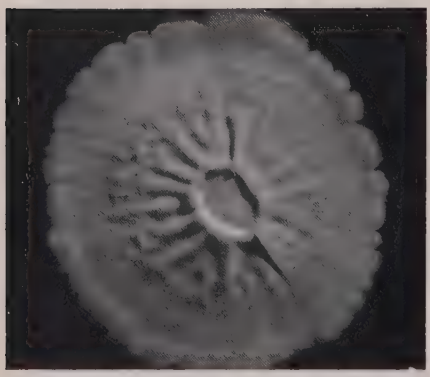
88. Cells from synthetic agar-A. Two unstained spores at *A*; long conjugation tube at *B*. Gram stained, × 1500.

Hansenula

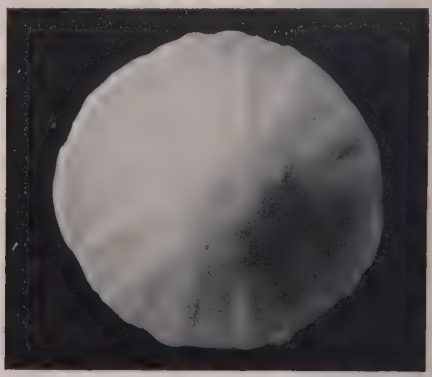
H. SUBPELLICULOSA BEDFORD (RY-135)



89. Sporulation on vegetable-juice agar at 1 month. Note two hat-shaped spores (brim to brim) emerging from ascus. Unstained, × 1500; enlarged, × 2.

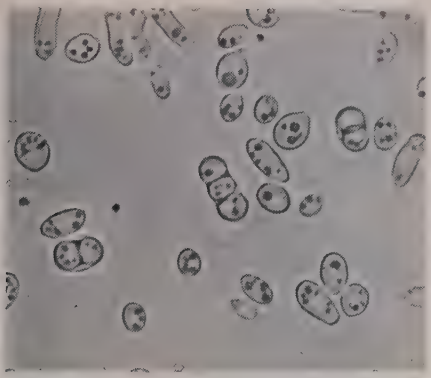


90. Giant colony grown on vegetable-juice agar; at 6 weeks. × 2½.



91. Giant colony grown on synthetic agar-A; at 6 weeks. × 3.

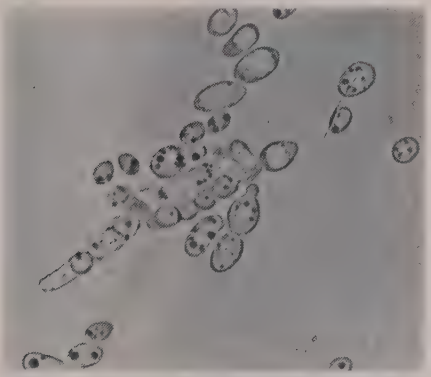
S. CEREVISIAE HANSEN (YD-15)



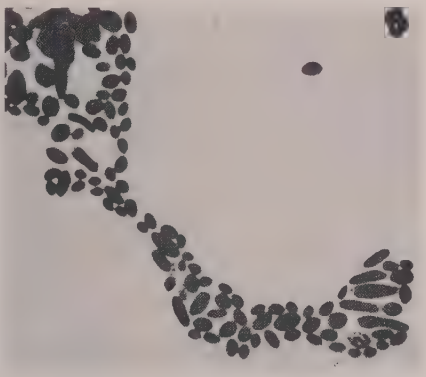
92. Two and 3 round to oval spores per ascus. From vegetable-juice agar at 2 months. Unstained, × 1500.

93. Cells from vegetable-juice agar; at 1 month. Gram stained, × 1500.

S. CEREVISIAE HANSEN (D-6)

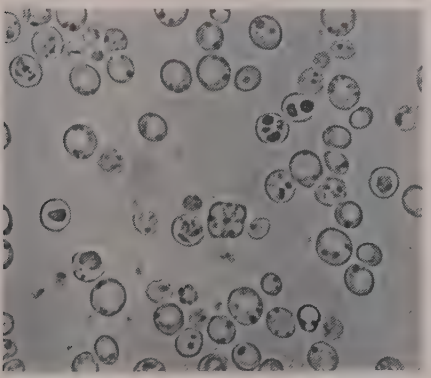


94. Asci with 4 round to oval spores each. From vegetable-juice agar at 1 month. Unstained, × 1500.

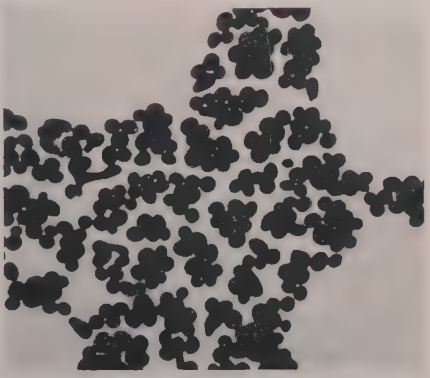


95. Cells from vegetable-juice agar at 1 month. Gram stained, × 1500.

S. GLOBOSUS OSTERW. (NY-114)



96. Typical round cells from vegetable-juice agar at 2 months. Four spores per ascus at lower center. Unstained, × 1500.

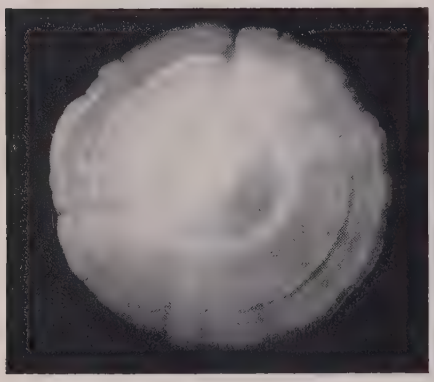


97. Young cells from synthetic agar-A at 7 days. Gram stained, × 1500.

Zygosaccharomyces s.g.

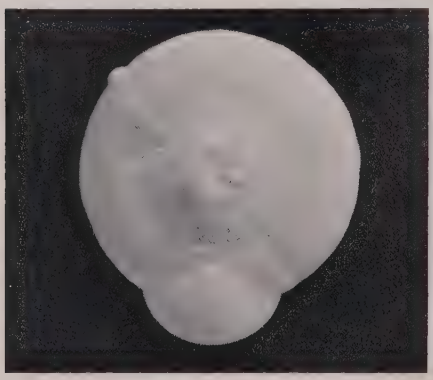
Z. GLOBIFORMIS KR. & KB.

Y-742 from brined cucumbers



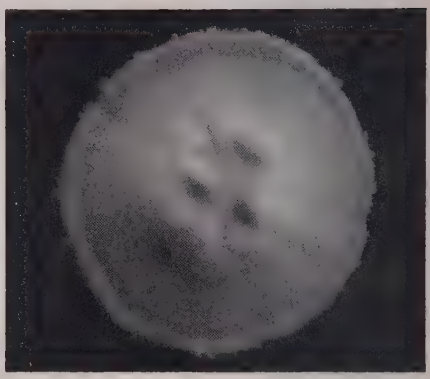
98. Giant colony grown on vegetable-juice agar; at 6 weeks. × 2½.

99. Giant colony grown on glucose agar; at 6 weeks. × 3½.

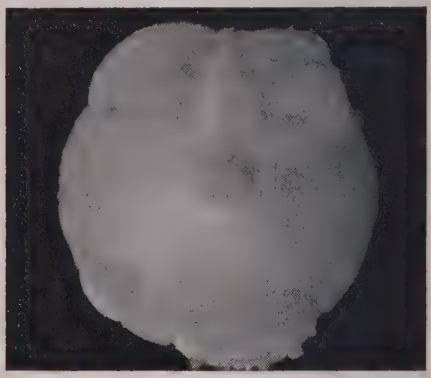


100. Giant colony grown on synthetic agar-A; at 6 weeks. × 3½.

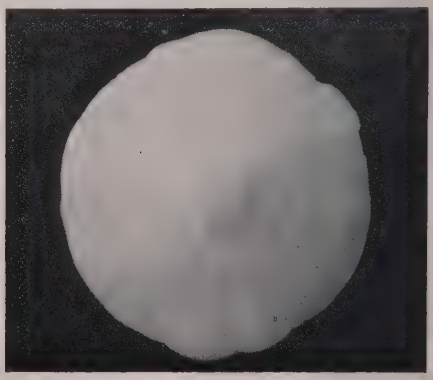
SPY-29 from spoiled sweet pickles



101. Giant colony grown on vegetable-juice agar; at 6 weeks. × 2½.



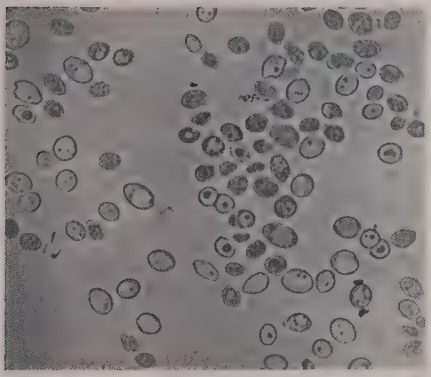
102. Giant colony grown on glucose agar; at 6 weeks. × 2½.



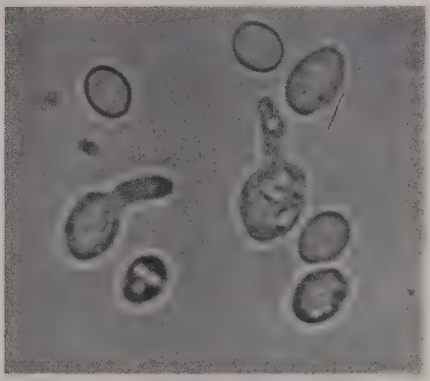
103. Giant colony grown on synthetic agar-A; at 6 weeks. × 3.

Z. GLOBIFORMIS (Cont.)

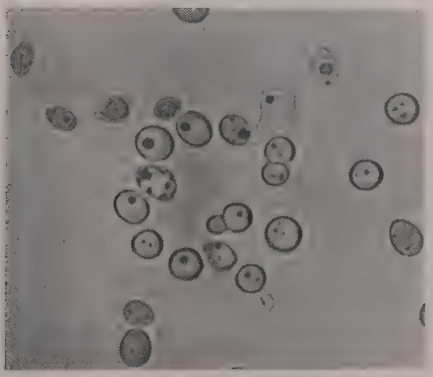
Y-742



104. Cells from vegetable-juice agar at 1 month with a few spores. Unstained, × 1500.

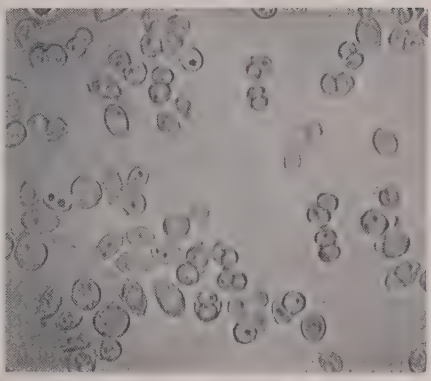


105. Cells with conjugation tubes from vegetable-juice agar at 1 month. Unstained, × 1500; enlarged, × 2.

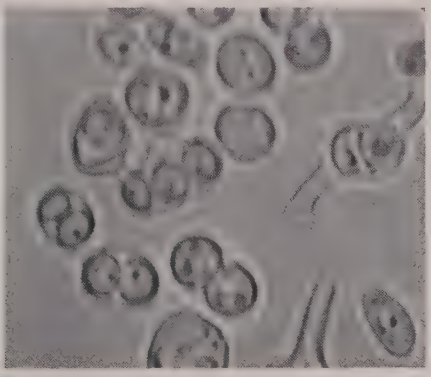


106. Free spores in center area, from vegetable-juice agar at 1 month. Unstained, × 1500; enlarged, × 2.

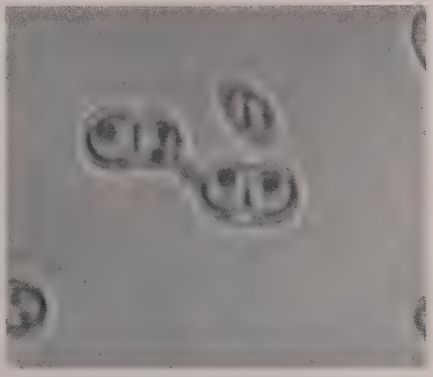
SPY-29



107. Sporulated culture from vegetable-juice agar at 1 month. Unstained, × 1500.



108. Asci with 4 spores. Center, 1 and 3 spores per side; lower left, 2 spores per side. Unstained, × 1500; enlarged, × 2.

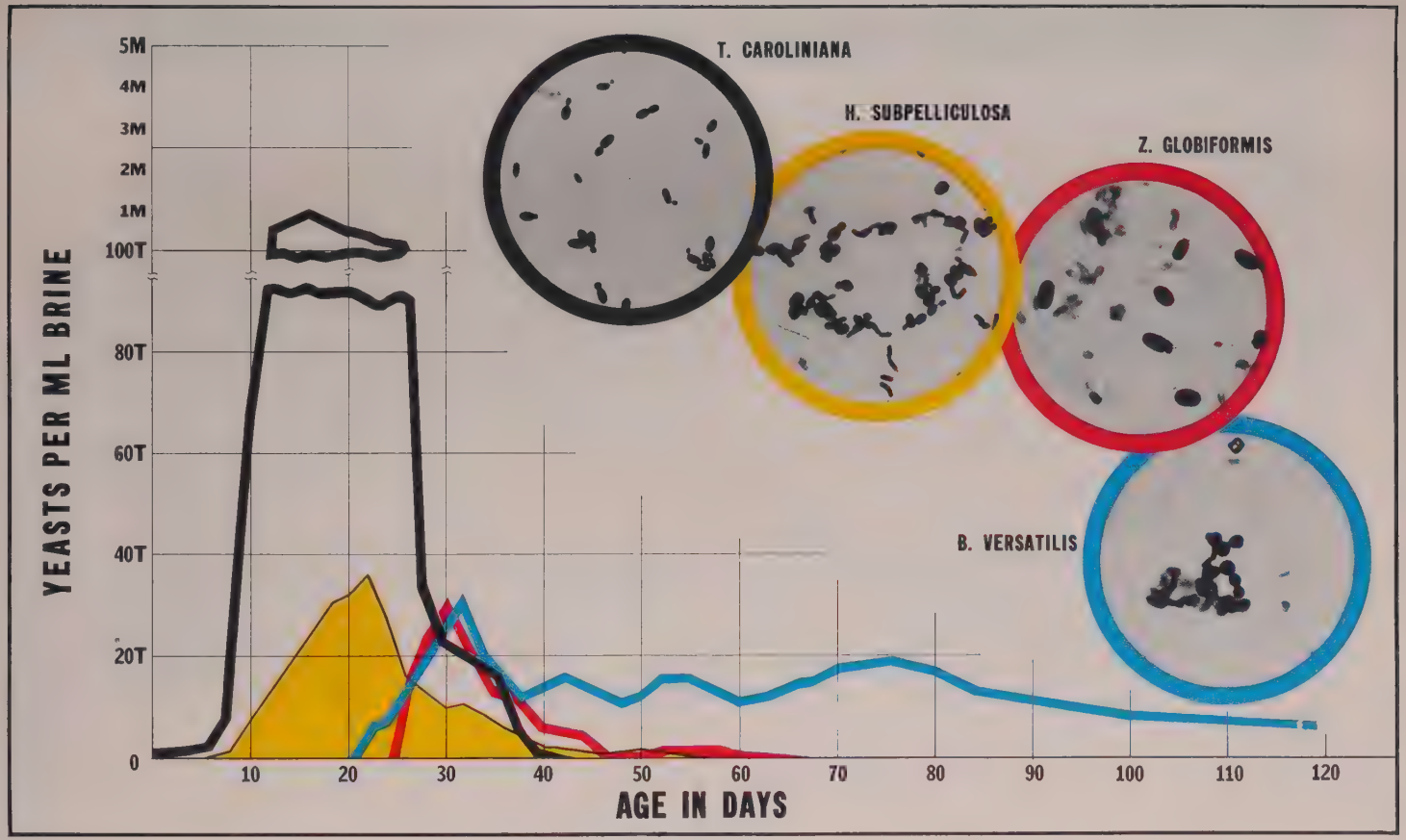


109. Ascus with two round spores per side. From vegetable-juice agar at 1 month. Unstained, × 1500; enlarged, × 2.

FROM NATURAL FERMENTATIONS FROM PURE CULTURE FERMENTATIONS

F. Examples of "bloater" formation by yeasts during the brine-fermentation of cucumbers. The four pairs of bloaters (at right) are typical of those produced by the 4 yeasts pictured below (p. 297).

110. BELOW. Yeast populations in commercial cucumber brines (T = thousands and M = millions) according to sequence of species (Cf. Etchells and Bell), (6). Inserts show 4 individual species as they occur naturally in brines during fermentation. Cells in brines Gram stained, × 1500.


T. CAROLINIANA
H. SUBPELLICULOSA
Z. GLOBIFORMIS
B. VERSATILIS
YEASTS PER ML BRINE
5M
4M
3M
2M
1M
100T
80T
60T
40T
20T
0
10
20
30
40
50
60
70
80
90
100
110
120
AGE IN DAYS

YEASTS FROM THE CUCUMBER PLANT

During the 1951 growing season, work was started to determine the numbers and species of yeasts associated with different parts of the cucumber plant *(Cucumis sativus)*. In the course of these studies, 966 yeast isolates were obtained from 37 sets of staminate and pistillate flowers, and five samples of small, immature fruit. These samples came from two important cucumber production areas in Eastern North Carolina. The details of the above study will be published elsewhere when the taxonomic work is complete; however, for our purpose here, certain remarks are in order.

More than one-half of the yeast cultures obtained during the study were asporogenic, non-fermentative, carotenoid-producing types placed in the genus *Rhodotorula*. Other yeast genera represented were: *Candida*, *Torulopsis*, *Debaryomyces*, *Torulaspora*, *Kloeckera*, *Saccharomyces s.s.*, and *Zygosaccharomyces s.g.* A breakdown of *Rhodotorula* isolates showed three major groups; red cultures similar to *R. glutinis*, yellow cultures similar to *R. flava*, and yellow cultures apparently not related to *R. flava*. In the minor red group were five rough strains with red-orange color; these produced rather well-developed mycelia. Several minor types were found among the yellow pigmented yeasts, including one that developed a latent black pigment.

In order to meet the accepted requirements of the genus *Rhodotorula* the presence of carotenoid pigments must be demonstrated. Further, with a large collection of isolates, the use of culture media that will aid in visual screening of potential pigmented species is of importance, particularly for the yellow types. A large number of the latter yeasts would have been missed had they not first been cultured on SYNTHETIC AGAR-B. Finally, the need for improved cultural and chemical techniques to clearly demonstrate carotenoid production in pigmented species cannot be minimized. The use of strong acids and alkalis has been found inadequate for liberating the pigments from yeast cells grown on liquid or solid media of conventional type. However, excellent results were obtained for pigment extraction with acetone only, providing the yeasts were grown in SYNTHETIC BROTH-B for 72 hours on a rotary shaker. The pigments were then transferred to petroleum ether for characterization by chromatography and determinations of absorption spectra.

Based on current work, which will be reported in detail elsewhere, it seems clearly evident that carotenoid production covers a wider range of yeast types than previously suspected. In the pages to follow, absorption maxima for total carotenoid pigments in petroleum ether accompany the illustrations of giant colonies of certain of the *Rhodotorula* isolated. Also, chromatographs on magnesium oxide-supercel columns with petroleum ether were made on cell extracts from four yeast types. The spectral analyses of the carotenoid zones, in terms of visually observed absorption maxima in mμ are given below.

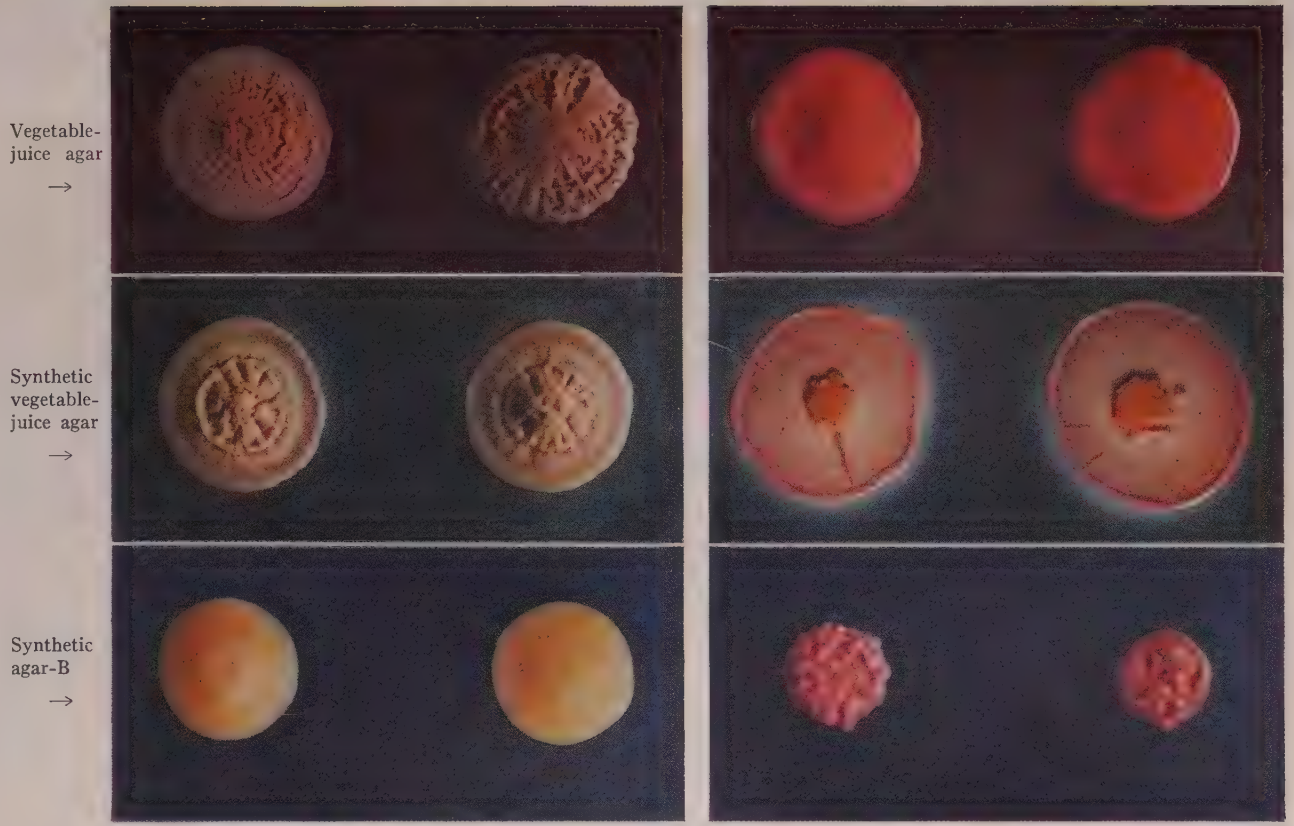
YEAST SY-85 (p. 300 LEFT), four pigments, Zone I, deep red, 485; II, red, 482 and 512; III, yellow, 460 and 488; IV, yellow (β-carotene), 450 and 475. YEAST SY-810 (p. 300 RIGHT), three pigments, Zone I, trace of pink; II, yellow orange, 450; III, yellow (β-carotene), 450 and 475. YEAST SY-875 (p. 301 RIGHT), four pigments, Zone I, deep red (sample lost); II, red, 435; III, yellow, 425 and 450; IV, yellow (β-carotene), 450 and 476. YEAST SY-836 (NOT SHOWN), one pigment, yellow (β-carotene), 450 and 474. β-carotene was identified as the pigment common to all four *Rhodotorula* species studied.

STAMINATE FLOWER AND BUDS | PISTILLATE FLOWER UNOPENED | PISTILLATE FLOWER OPENED | IMMATURE FRUIT WITH DRIED FLOWER

G. Flowers and immature fruit of the cucumber plant (*Cucumis sativus*). White spine variety; about actual size.

H. Comparative growth of 2 cultures of *Rhodotorula glutinis* group on 3 cultural media; 6 weeks' incubation at room temp.; × 1⅓. Absorption max. for culture SY-761 (left), 447 mμ; SY-85 (right), 480 mμ.

I. Comparative growth of 2 cultures of *Rhodotorula flava* group on 3 cultural media; 6 weeks' incubation at room temp.; × 1⅓. Absorption max. for both cultures, SY-873 (left) and SY-810 (right), 450 mμ.

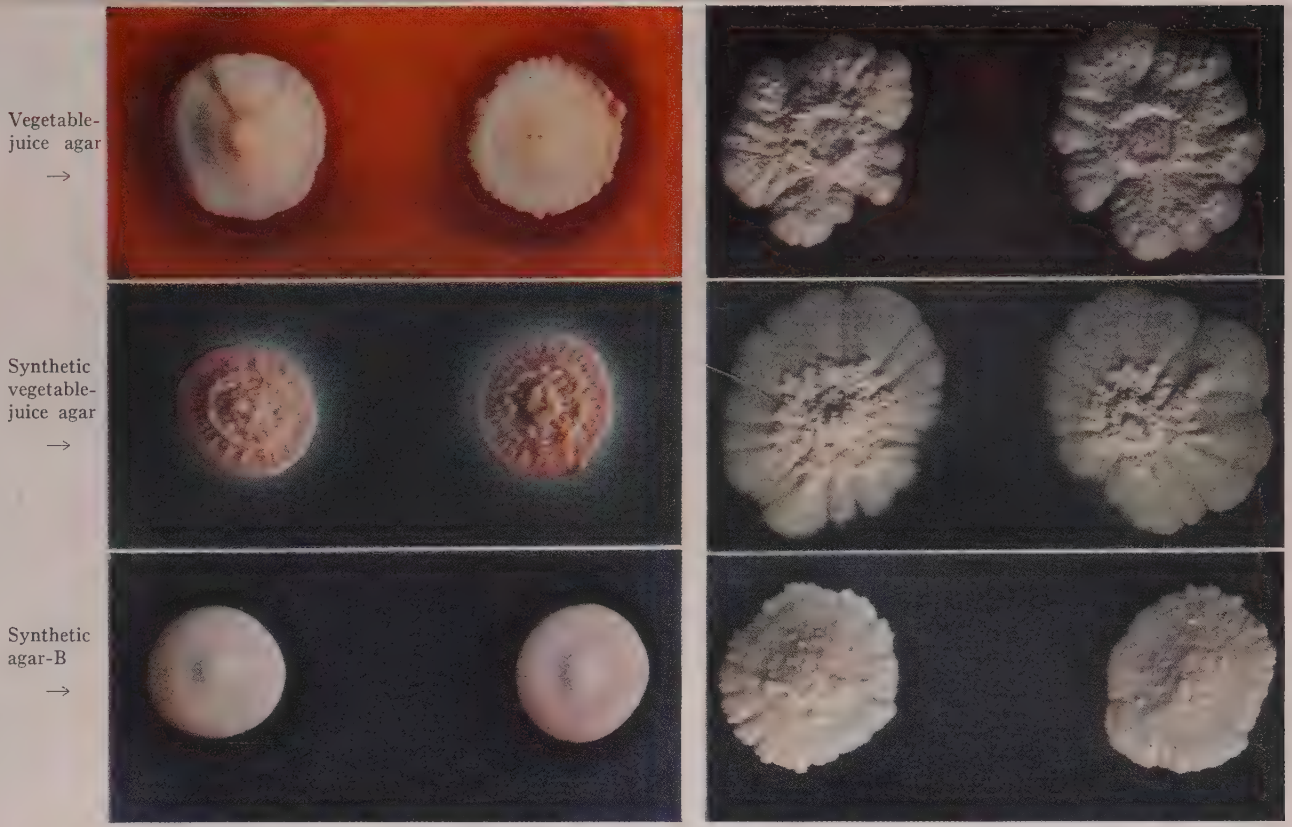


J. Comparative growth of 2 cultures of rough, yellow *Rhodotorula* species on 3 cultural media; 6 weeks' incubation at room temp.; × 1⅓. Absorption max. for both cultures, SY-629 (left) and SY-665 (right), 445 mμ.

K. Comparative growth of 2 cultures of rough, mycelia-producing *Rhodotorula* species on 3 cultural media; 6 weeks' incubation at room temp.; × 1⅓. Absorption max. for both cultures, SY-1070 (left) and SY-875 (right), 450 mμ.

L. Comparative growth of 2 miscellaneous *Rhodotorula* cultures on 3 cultural media; 6 weeks' incubation at room temp.; × 1⅓. Absorption max. for SY-364 (left), 450 mμ; SY-369 (right) not determined.

M. Comparative growth of *Rhodotorula* culture SY-1054 on 3 cultural media. *Left:* colonies grown 4 weeks at room temp. *Right:* the same colonies after an additional 3 weeks in the refrigerator (6°C.). Absorption max., 440 mμ.



N. Comparative growth of 2 pigmented cultures SY-161 (left) and SY-173 (right) of *Candida pulcherrima* on 3 cultural media; 6 weeks' incubation at room temp.; × 1⅓. Pigments soluble in the media; cells from both cultures negative for carotenoids.

O. Comparative growth of 2 cultures SY-188 (left) and SY-177 (right) of rough, fermentative *Candida* species on 3 cultural media; 6 weeks' incubation at room temp.; × 1⅓. Cells from both cultures negative for carotenoids.

ACKNOWLEDGMENTS

We wish to express sincere appreciation to the following Station personnel for generous assistance received: Dr. W. J. Peterson, Head, Department of Chemistry, and Dr. W. W. G. Smart, Jr., Department of Animal Industry, for their fine work on extraction and characterization of the carotenoid pigments; Messrs. N. S. Youngsteadt and Lane Palmer, Department of Publications, for their many hours devoted to planning, layout and art work; Mrs. Elsie Harper, Department of Visual Aids for special photographic printing; Dr. R. W. Cummings, Director of Research for the Station, and Professor M. E. Gardner, Head, Department of Horticulture, for their support and cooperation throughout this study. Notable contributions have also been made by Mr. A. L. Demain, University of California, who helped with isolation and identification studies during the summer of 1951; by Mr. L. P. Watson, Raleigh, N. C., who made the color pictures; and, by Mr. Robert Stevens, Lynchburg, Va., who was in charge of reproducing the natural color photographs. Our sincere thanks are given to Dr. Edgar V. Seeler, Editor of Farlowia, and the late Dr. W. Lawrence White, Director of the Farlow Library and Herbarium, Harvard University, for their advice and encouragement during the preparation of this article.

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4(3):305–351 FARLOWIA NOVEMBER, 1953

THE USTILAGINALES OF CHINA

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The fungus flora of China has been relatively little studied in contrast to the progress made in exploring her well known richness in phanerogams. Until recent decades, fungi were gathered there only incidentally by collectors of flowering plants. These collections have been named by a number of western botanists and are scattered in various herbaria of Europe and America. Most of them have never been re-examined. In order to set forth the nature and extent of her fungus flora, all these collections must be studied critically group by group.

During the past several years the writer tried to locate all collections of the Ustilaginales recorded from China, especially the types of species described from there. Through the courtesy of various herbaria, most of them were made available for study. His former colleagues assisted him in gathering new collections. As a result, the present treatment of these fungi, after placing a number of binomials in synonymy and excluding others as incorrectly identified, includes 105 species, 3 varieties and 1 form. Whenever accessible, type specimens of species related to those occurring in China and known from neighboring areas, were examined to ascertain their relationships; thereby a number of synonyms was added.

Besides the writer's personal collection, the materials considered here are from the following sources: Mycological Collections, Bureau of Plant Industry, U. S. Department of Agriculture; U. S. National Museum; Farlow Herbarium, Harvard University; Naturhistorisches Museum, Vienna; Universitetes Institution för Systematisk Botanik, Uppsala; Naturhistoriska Riksmuseet, Stockholm; Herbarium of the Faculty of Agriculture, Hokkaido Imperial University; University of Nanking; National Tsin Hua University; National Taiwan University; and Taiwan Agricultural Research Institute.

The writer acknowledges his deep indebtedness to Mr. J. A. Stevenson for granting him the facilities of the Mycological Collections, Bureau of Plant Industry, U. S. Department of Agriculture, for his assistance in various ways, and for his review of the manuscript. He is also grateful to Miss Edith K. Cash for preparing the Latin diagnoses; to the late Dr. Th. Arwidsson, Dr. R. Ciferri, Dr. S. Ito, Dr. T. Matsumoto, Dr. J. A. Nannfeldt, Dr. F. Petrak, Mr. K. Sawada, Prof. F. L. Tai, Dr. C. T. Wei, and Dr. W. Lawrence White, through whose kindness specimens were made available for study; to Mrs. Agnes Chase, Dr. A. N. Steward, Mr. J. R. Swallen, and Dr. E. H. Walker for the identification of certain host plants.

TILLETIACEAE

Sori usually dehiscent at maturity in *Tilletia* and *Urocystis* but indehiscent in other genera. Spore germination by means of a cylindrical promycelium on which a terminal cluster of elongate sporidia is borne. Promycelium usually non-septate until its cytoplasm becomes highly vacuolated. Sporidia usually function as reproductive organs. Conidia often produced.

TILLETIA Tul.

Ann. Sci. Nat. III. 7: 112. 1847.

Sori in various parts of the host, most frequently in the ovaries. Spore mass usually dusty at maturity. Spores not aggregated into balls, of medium to large size.

Several species of *Tilletia*, including *T. horrida*, have been transferred to the genus *Neovossia* Koern. which, as emended by Brefeld, is characterized by forming a large number of sporidia on germination which do not fuse *in situ*. Since our knowledge of the spore germination of this group of fungi is limited to relatively few species, it will not be surprising if certain species are found in the future with sporidia intermediate in number. As concerns the lack of direct sporidial fusion, it indicates merely that the primary sporidia may function as propagative cells as well as reproductive organs. The conjugation may be delayed to a later stage. Recent studies have shown that even in a single species the homothallic forms may occur along with the heterothallic forms. Sexuality, therefore, cannot be considered as of taxonomic value. Furthermore, if the characters and behavior of sporidia are so important in taxonomy, it is difficult to understand why such genera as *Ustilagidium* Herzb. and *Anthracoidea* Bref. are constantly rejected.

Spores smooth	*T. foetida*
Spores reticulate	
Reticulations 2–4 μ wide	*T. caries*
Reticulations 1.2–2 μ wide	*T. rhei*
Spores with spiny scales	
Sori surrounding the branches of inflorescence	*T. okudaire*
Sori in the ovaries or vegetative organs	
Mature spores light yellow	*T. alopecuri*
Mature spores dark brown	
Sori completely concealed by the glumes	*T. horrida*
Sori more or less exposed	
Sori exceeding 4 mm. in length	
Mature spore with an evident hyaline envelope	*T. pennisetina*
Mature spore without an evident hyaline envelope	*T. setariae*
Sori under 4 mm. in length	
Spores 26–36 μ diam.	*T. arundinellae*
Spores 20–31 μ diam.	*T. pulcherrima*
Spores 19–26 μ diam.	*T. deyeuxiae*

Tilletia alopecuri (Saw.) Ling, Mycologia 41: 252. 1949.

Entyloma alopecuri Saw., Dept. Agr. Gov't. Res. Inst. Formosa Rep. 2: 86. 1922.

Sori in the ovaries, infecting most of the spikelets in the inflorescence, inconspicuous, hidden completely by the enveloping glumes and each covered by a thin membrane of host tissue, broadly ellipsoid with a tapering apex, approximately 1 mm. long; also in leaves, leaf sheaths and internodes of culms, subepidermal, forming short or elongate yellow striae, later becoming dark brown, often causing hypertrophy, curvature and bulging of the culms. Spores light yellow, spherical to subspherical, each enclosed in a hyaline envelope, 17–25.5 μ diam., averaging 22.2 μ, covered with prominent spiny scales measuring 2–3 μ high by 2.5–3.5 μ wide at base; immature

spores or sterile cells almost hyaline, 12–16.5 μ diam., epispore 1.5 μ thick; conidia on the surface of infected vegetative tissue of the host, hyaline, smooth, 14–35 x 5–8 μ.

On Gramineae:

Alopecurus geniculatus L.

Type locality and host: Taipeh, Taiwan, on *Alopecurus geniculatus*.

Distribution: Taiwan.

Tilletia arundinellae Ling, Myc. Papers Imp. Myc. Inst. 11: 1. 1945. (Fig. 1,A)

Sori in the ovaries, inconspicuous, protruding between the spreading glumes, cornute or conical, 3.5–4 mm. long, 1–1.5 mm. wide, each covered by a firm purplish membrane which ruptures irregularly revealing a black pulverulent spore mass. Spores when mature dark purplish brown, opaque, chiefly spherical to subspherical, 25.5–36 μ, mostly 28.5–31.5 μ diam., with hyaline, usually curved spinous scales, 1.5 μ long and 1–1.4 μ wide at base, each enclosed by an evident hyaline membrane; sterile cells subhyaline, thick-walled, mostly smaller than the spores, often with pedicel-like projections.

On Gramineae:

Arundinella anomala Steud.

Type locality and host: Chengtu, Szechwan, on *Arundinella anomala*.

Distribution: Known only from the type locality.

Tilletia caries (D.C.) Tul., Ann. Sci. Nat. III. 7: 113. 1847.

Uredo caries DC., Fl. Franç. 6: 78. 1815.

Tilletia tritici Wolff, Brand Getreides 13. 1874.

Sori in the ovaries, oval, enclosed by the pericarps, about same size as the wheat kernels. Spores when mature dark olive brown, chiefly spherical to subspherical, 15–20 x 14–18 μ, with shallow to deep winged reticulations, 2–4 μ wide, foetid.

On Gramineae:

Triticum aestivum L.

Type locality and host: France, on *Triticum aestivum*.

Distribution: Chekiang, Honan, Hopeh, Kansu, Kiangsu, Shansi, Shensi, Sikang, Szechwan, Yunnan, Chahar, Tsinghai, Suiyuan, Sunkiang, Hokiang, Heilungkiang, Nunkiang, Hsingan; also in all of the wheat growing countries.

Tilletia deyeuxiae Ling, Myc. Papers Imp. Myc. Inst. 11: 1. 1945. (Fig. 2,A)

Sori in the ovaries, infecting only occasional ones, ovoid, 3–4 mm. long, protected at first by the ovary walls which rupture at maturity disclosing the dark dusty spore masses. Spores when mature dark olive brown, opaque, spherical to ovoid, occasionally ellipsoid or somewhat angular, 18.5–26 x 16–24.5 μ, averaging 21 x 19 μ, densely covered by hyaline spiny scales, 1–1.5 μ long, 0.7–1.3 μ wide at base, and each enveloped by an evident hyaline membrane often with a short tapering projection at the end of attachment; sterile cells numerous, hyaline, chiefly subspherical, thick-walled, smooth, considerably smaller than the spores, averaging 13.6 x 11.2 μ.

On Gramineae:

Deyeuxia sylvatica (Schrad.) Kunth. var. *laxiflora* Rendle

Type locality and host: Sunghsien, Honan, on *Deyeuxia sylvatica* var. *laxiflora*.

Distribution: Known only from the type locality.

Tilletia foetida (Wallr.) Liro, Maanviljelys-taloudellinen Koelaitos Vuosikirja 1915–16. 27. 1920.

Erysibe foetida Wallr., Fl. Crypt. German. 2: 213. 1833.

Tilletia laevis Kuehn, Hedwigia 12: 152. 1873.

Tilletia foetens Schroet., in Cohn's Beitr. Biol. Pfl. 2: 365. 1877.

Sori in the ovaries, oval, enclosed by the pericarps, about same size as wheat kernels. Spores globose to ellipsoid, occasionally oblong or angular, light grayish brown to olive brown, smooth, 15–30 x 13–20 μ, foetid.

On Gramineae:

Triticum aestivum L.

Type locality and host: Germany, on *Triticum aestivum*.

Distribution: Hopeh, Kiangsu, Shansi, Shensi, Sikang, Szechwan, Yunnan, Kansu, Chahar, Suiyuan, Kirin, Sunkiang, Hokiang, Nunkiang, Heilunkiang, Hsingan; also in all of the wheat growing countries.

Tilletia horrida Tak., Bot. Mag. Tokyo 10: 20. 1896.

Neovossia horrida Padw. & Azmatullah Khan, Myc. Papers Imp. Myc. Inst. 10: 2. 1944.

Sori in the ovaries, infecting only occasional ones, completely or partially destroying the endosperm, concealed by the glumes. Spores present in various stages of development, when mature dark olive brown and opaque, each enveloped by an evident hyaline membrane, chiefly spherical to subspherical, 22–33 μ diam., with coarse, hyaline, somewhat curved scales, 2–3 μ wide at base; immature spores hyaline, thick-walled.

On Gramineae:

Oryza sativa L.

Type locality and host: Tokyo, Japan, on *Oryza sativa*.

Distribution: Chekiang, Hopeh, Kiangsi, Kiangsu, Liaoning, Szechwan, Taiwan, Yunnan; also in Burma, India, Indo-China, Japan, Java, Philippine Islands, Russia, America.

Tilletia okudairae (Miyabe) comb. nov.

Ustilago okudairae Miyabe apud S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 88. 1935.
Tilletia taiana Mundk., Trans. Brit. Myc. Soc. 24: 328. 1940.

Sori infecting the branches of inflorescences and inhibiting the development of racemes, concealed at first by leaf sheaths, then protruding, after the dispersal of olivaceous black spore masses leaving behind the naked branches. Spores olive brown, globose to ellipsoid, rarely somewhat irregular, 10–16.5 x 9–14 μ, with winged polygonal reticulations, 3–4.5 μ wide and 1.5 μ deep; sterile cells in chains intermixed with the spores, thick-walled, light olivaceous brown, chiefly cubical or subglobose, 6–10.5 μ in width.

On Gramineae:

Coix agrestis Lour.

Type locality and host: Iyo, Japan, on *Coix agrestis*.

Distribution: Yunnan; also in Japan.

Tilletia pennisetina Syd., Ann. Myc. 27: 421. 1929.

Neovossia macrospora Petr., Meddel. från Göteb. Bot. Trädg. 17: 114. 1947.

Sori in the ovaries, infecting only a few spikelets in a panicle, broadly oval, 4–7 mm. long, 2–3 mm. wide, each covered by a green, smooth membrane of host tissue which ruptures later disclosing a black, pulverulent spore mass. Spores showing different stages of development, spherical to subspherical, occasionally ellipsoid or oblong, when mature dark olive brown and opaque, 21.5–33 x 21–28.5 μ, with hyaline, slightly curved, aculeate scales, 1.5–2.5 μ long, each enveloped by an evident hyaline membrane often with a tapering pedicel at the end of attachment; immature spores subhyaline to light olivaceous brown, smooth or echinulate; sterile cells often also present, much larger than the spores, thin-walled.

On Gramineae:

Pennisetum alopecuroides (L.) Spreng. (= *P. japonicum* Trin., *P. compressum* R. Br.)

Type locality and host: Kuling, Kiangsi, on *Pennisetum alopecuroides*.

Distribution: Anhwei, Hopeh, Hunan, Hupeh, Kiangsi, Kiangsu, Szechwan; also in India, Korea, Japan.

Tilletia pulcherrima Ell. & Gall. apud Clint., Proc. Boston Soc. Nat. Hist. 31: 441. 1904.

Sori in the ovaries, infecting only a few spikelets in a raceme, ovoid or cornute, partially exposed between spreading glumes, 2.5–4 mm. long. Spores yellow brown to opaque varying with the degree of maturity, chiefly spherical to subspherical, 19.5–31.5 μ, averaging 25.6 μ in diameter, each with an evident hyaline membrane and prominent, hyaline, straight or slightly curved, truncate scale-like projections, 2–2.5 μ long and 1.6–2 μ wide at base; sterile cells hyaline, thick-walled, 18–28.5 μ diam.

On Gramineae:

Digitaria sanguinalis (L.) Heist.

Echinochloa crus-galli (L.) Beauv.

Type locality and host: Illinois, United States, on *Panicum virgatum* L.

Distribution: Liaoning, Szechwan; also in Japan, Russia, North America.

Tilletia rhei Zundel, Mycologia 36: 410. 1944. (Fig. 3,A)

Sori destroying the seeds, deforming each into a hard, triangular, mummified mass, approximately 2.5 mm. long, 2 mm. wide. Spore mass agglutinate, black at the surface of infected seed but white in the interior, intermixed with starch grains which are abundantly present in the endosperm of the healthy seed. Spores spherical to oval, occasionally slightly angular, 16.5–19.5 μ diam., or 18–24 x 16.5–19.5 μ, epispore orange brown at maturity, with winged polygonal reticulations 1.2–2 μ wide and 1–1.4 μ deep; immature spores present in different stages of development, from hyaline and smooth to light yellow and reticulate, usually slightly larger than the mature ones.

On Polygonaceae:

Rheum franzenbachii Muert.

Type locality and host: Yünting-shan, Chiaocheng, Shansi, on *Rheum franzenbachii*.

Distribution: Known only from the type locality.

Tilletia setariae Ling, Myc. Papers Imp. Myc. Inst. 11: 2. 1945.

Sori in the ovaries, infecting only occasional ones, ovoid or broadly oval, 4–5 mm. long and 2.5–3 mm. wide, each covered at first by a thick, green, smooth membrane of host tissue; spore mass black, pulverulent. Spores showing different stages of development, opaque brown when mature, chiefly spherical to subspherical, occasionally oval, 21.5–33 μ, mostly 22–28.5 μ diam., with blunt, subhyaline or light brownish scales, 1.5–2.5 μ long, with hyaline envelopes present only at very young stage; sterile cells few, hyaline, thick-walled, mostly smaller than the spores.

On Gramineae:

Setaria lutescens (Weigel) Hubbard

Type locality and host: Chengtu, Szechwan, on *Setaria lutescens*.

Distribution: Known only from the type locality.

ENTYLOMA D. By.

Bot. Zeit. 32: 101. 1874.

Sori usually in the leaves, embedded permanently in the host tissue, indehiscent. Spores either scattered or adhering together, but not forming definite balls, most frequently light-colored, of medium size.

Spores firmly adhering together	
Spores 9–12 μ long	*E. eleocharidis*
Spores 6–10 μ long	*E. oryzae*
Spores readily separable	
Epispores 3–6 μ thick	*E. microsporum*
Epispores under 3 μ thick	
Mature spores yellowish to golden brown	*E. australe*
Mature spores scarcely colored	
Spores densely crowded, 11–18 μ long	*E. guaraniticum*
Spores abundant but not crowded, 9–15 μ long	*E. compositarum*

Entyloma australe Speg., Anal. Soc. Cien. Argent. 10: 5. 1880.

Sori in the leaves, often also in the calyxes, forming yellow to dark brown, circular to angular spots, 0.5–7 mm. in length. Spores globose to oval, sometimes ovoid or somewhat angular, 10–16.5 x 9–13.5 μ; epispore smooth, light yellowish to golden brown, 2–3 μ thick, apparently double-layered, outer layer thicker, frequently irregular and crenate.

On Solanaceae:

Physalis angulata L.

Physalis ? minima L.

Type locality and host: Duncan, Argentina, on *Physalis pubescens* L.

Distribution: Kiangsu, Taiwan; also in Indo-China, Japan, Africa, North and South America.

Entyloma compositarum Farl., Bot. Gaz. 8: 275. 1883.

Entyloma senecionis Saw., Jour. Taihoku Soc. Agr. For. 7: 27. 1934.

Sori in the leaves, forming angular, brown spots, limited by the veins, 0.5–1.5 mm. long, often confluent. Spores spherical to oval, occasionally ellipsoid, 9–13 μ diam., or 10.5–14.8 x 7.5–12 μ; epispore subhyaline to pale yellowish, smooth, 0.6–1 μ thick.

On Compositae:

Senecio formosana Kitamura

Type locality and host: New England, United States, on *Aster puniceus* L.

Distribution: Taiwan; also in North America.

Entyloma bavaricum Syd. differs from this species in having much thicker epispores.

Entyloma eleocharidis (Saw.) Ling, Mycologia 41: 255. 1949. (Fig. 1,B)

Ustilago eleocharidis Saw., Taiwan Agr. Res. Inst. Rep. 85: 39. 1943.

Sori in the upper parts of the culms, circular or irregular in shape, lead black, 0.1–1 mm. long. Spores embedded permanently in the host tissues between the upper and lower epidermis, arranged in parallel columns, firmly agglutinated together, globose to subglobose, often angular, 9–12 x 7–10.5 μ; epispore thin, smooth, light olivaceous brown.

On Cyperaceae:

Eleocharis dulcis Trin.

Type locality and host: Taipeh, Taiwan, on *Eleocharis dulcis*.

Distribution: Known only from the type locality.

Entyloma guaraniticum Speg., Anal. Soc. Cien. Argent. 17: 127. 1884.

Protomyces bidentis Saw., Dept. Agr. Gov't. Res. Inst. Formosa Rep. 2: 53. 1922.

Sori in the leaves, forming subcircular, indistinct spots, 1–4 mm. diam., brownish on the lower surface and dark greenish on the upper. Spores densely embedded in the mesophyll, globose to oval, occasionally ovoid, ellipsoid or oblong, 10.5–13.5 μ diam. or 12–18.5 x 8–11 μ; epispore 1.2–2.2 μ thick, smooth, pale yellowish.

On Compositae:

Bidens pilosa L.

Type locality and host: Paraguay, on *Bidens pilosa*.

Distribution: Taiwan; also in North and South America.

Entyloma bidentis P. Henn. (type in Myc. Coll. BPI. U. S. Dep. Agr.) on the same host genus is characterized by its yellow to golden yellow epispore measuring 2–4 μ thick. The size of spores, however, is similar to that of this species.

Entyloma microsporum (Ung.) Schroet., in Rab. Fungi Eur. 1872. 1874.

Protomyces microsporus Ung., Exanth. Pfl. 343. 1833.

Sori in the leaves, often also in the petioles and stems, causing deformation of the infected organs, forming hard, fusoid to hemispherical pustules, thick and elevated, 1–7 mm. in length, yellowish to dark brown according to the age. Spores variable in shape, subglobose to ellipsoid or ovoid, sometimes irregular, often with one or both ends tapering like pedicels, 14–25 x 10–17 μ; epispore usually somewhat crenate, hyaline at first, becoming light yellow to light yellow brown, smooth, 3–6 μ thick; conidia falcate, hyaline, 10–18 x 3.5–4 μ.

On Ranunculaceae:

Ranunculus vernyii Fr. & Sav.

Type locality and host: Europe, on *Ranunculus repens* L.

Distribution: Taiwan; also in Europe, North America.

Entyloma oryzae Syd., Ann. Myc. 12: 197. 1914.

Ectostroma oryzae Saw., Formosan Agr. Rev. 6 (63): 107. 1912.

Sclerotium phyllachoroides Hara, Jour. Pl. Prot. Tokyo 2: 949. 1915.

Sori in the leaves, forming short black striae, up to 2.5 mm. in length, permanently covered by the epidermis. Spores firmly and compactly agglutinated together, mostly angular, chiefly 6–10 x 4.7–7.5 μ; epispore smooth, 0.5–0.8 μ thick, light olivaceous brown.

On Gramineae:

Oryza sativa L.

Type locality and host: Laguna, Philippine Islands, on *Oryza sativa*.

Distribution: Anhwei, Chekiang, Fukien, Hupeh, Kiangsi, Kiangsu, Antung, Kirin, Szechwan, Taiwan, Yunnan; also in Afghanistan, Burma, India, Japan, Philippine Islands, Russia, America.

This species, though very similar to, is not identical with *Entyloma lineatum* (Cke.) Davis. The spores of *E. lineatum* although light in color, are bright golden brown and lack the dull olivaceous tinge of *E. oryzae* even in mass.

UROCYSTIS Rab.

Kl. Herb. Viv. Myc. II. 393. 1856.

Sori in various parts of the host, most frequently in the leaves, dehiscent and usually pulverulent at maturity. Spore-balls permanent, each composed of one to several spores invested by few to many sterile cells. Spores generally dark-colored, of medium size.

Sori forming regular linear striae	*U. agropyri*
Sori forming rather irregular pustules	
Cortical cells incompletely investing the spores	*U. anemones*
Cortical cells completely investing the spores	
Spores usually 1–3 in the balls	*U. dioscoreae*
Spores usually 3–6 in the balls	*U. japonica*

Urocystis agropyri (Preuss) Schroet., Abh. Schles. Ges. Nat. Med. 1869–72: 7. 1871.

Uredo agropyri Preuss, in Sturm Deuts. Fl. Pilze 6:1. 1848.
Urocystis tritici Koern., Hedwigia 16: 33. 1877.

Sori in the leaves, leaf sheaths and upper culms, forming linear striae of varying length, at first lead-colored and protected by the epidermis which soon ruptures. Spore-balls globose to ellipsoid, 18–35 μ long, composed of 1–3, rarely 4, fertile spores and an investing layer of sterile cells. Sterile cells subhyaline to light brown, subglobose to ellipsoid, 4–15 x 4–7 μ. Spores globose to oval, 12–18 x 11–15 μ; epispore reddish brown, smooth.

On Gramineae:
Agropyron sp.
Triticum aestivum L.

Type locality and host: Hoyerswerda, Germany, on *Agropyrum repens* Beauv.

Distribution: Chekiang, Honan, Hopeh, Hupeh, Kiangsu, Shantung, Shensi, Sunkiang, Szechwan; also in Afghanistan, India, Japan, Palestine, Russia, Africa, America, Australia, Europe.

Urocystis anemones (Pers.) Wint., in Rab. Krypt. Fl. 1: 123. 1881.

Uredo anemones Pers., Syn. Fung. 223. 1801.
Tuburcinia anemones Liro, Ann. Univ. Fenn. Aboensis A. 1: 55. 1922.

Sori in the leaves, petioles and stems, forming conspicuous, irregular galls, upon rupture of the covering host tissue disclosing the black, dusty spore masses. Spore-balls subglobose to oval, often irregular, 19.5–38 x 16.5–30 μ, consisting of 1–6 spores usually incompletely invested by a number of sterile cells. Sterile cells subglobose to oblong, pale yellowish to pale brown, 7–12 x 5–7 μ. Spores deep reddish brown, subglobose to oval, frequently oblong or somewhat irregular, smooth, 12–21 x 8–15 μ.

On Ranunculaceae:
Anemone raddeana Regel
Pulsatilla chinensis (Bge.) Regel (= *Anemone chinensis* Bge.)

Type locality and host: Europe, on *Anemone nemorosa* L.

Distribution: Kiangsu, Antung; also in Japan, Russia, Europe, North America.

Urocystis dioscoreae Syd., Ann. Myc. 8: 173. 1909.

Tuburcinia dioscoreae Liro, Ann. Univ. Fenn. Aboensis A. 1: 38. 1922.

Sori in the leaf veins and petioles, forming elongate pustules, causing distortion of the infected organs, covered at first by the host tissue which ruptures later revealing the dusty black spore masses. Spore-balls globose to oblong, sometimes irregular, composed of usually 1, often 2–3 spores completely invested by a layer of sterile cells. Peripheral sterile cells subglobose to ellipsoidal, compressed, chiefly 6–12 μ long, light yellowish brown. Spores globose to oval, often oblong, dark reddish brown, smooth, 10–16.5 x 9–12.5 μ.

On Dioscoreaceae:
Dioscorea quinqueloba Thunb.

Type locality and host: Tosa, Japan, on *Dioscorea tokoro* Makino.

Distribution: Honan; also in Japan.

Urocystis japonica (P. Henn.) Ling, Myc. Papers Imp. Myc. Inst. 11:3. 1945.

Urocystis anemones (Pers.) Wint. var. *japonica* P. Henn., Hedwigia 43: 150. 1904.
Tuburcinia japonica Liro, Ann. Univ. Fenn. Aboensis A. 1: 65. 1922.

Sori in the leaves, petioles and stems, forming conspicuous and irregular galls of considerable size, usually causing distortion to the host, upon rupturing of the covering host tissue disclosing the semi-agglutinate black spore masses. Spore-balls dark

reddish brown, subglobose to oval, often irregular, 18–45 μ in length, consisting of 3–12 fertile spores completely invested by a layer of sterile cells. Sterile cells pale olivaceous brown to cinnamon brown, oval, ellipsoid or oblong, compressed, 7.5–13.5 x 6–9 μ, rarely up to 17 μ long. Spores deep ochraceous brown, globose to ellipsoid, or somewhat irregular, smooth, 12–16 x 9–12.5 μ.

On Ranunculaceae:

Anemone japonica Sieb. & Zucc.

Anemone sp.

Type locality and host: Tosa, Japan, on *Anemone japonica*.

Distribution: Jehol, Szechwan; also in Japan.

BURRILLIA Setch.

Proc. Amer. Acad. 26: 18. 1891.

Sori generally in the leaves, permanently embedded in the host tissues, indehiscent. Spore-ball without a distinct cortex, composed of numerous spores, in some species with sterile parenchymatous cells in the center or intermixed with the spores. Spores light-colored, of medium size.

Burrillia ajrekari Thirumalachar, Mycologia 39: 607. 1947. (Fig. 3,B)

Stereosorus monochoriae Saw., Taiwan Agr. Res. Inst. Rep. 85: 45. 1943.

Sori in the leaves, punctiform, densely aggregated in circular to irregular spots of 3–15 mm. long, which are chlorotic on the lower surface and brownish on the upper side and sometimes coalescing. Spore-balls embedded in the mesophyll, oval to ellipsoidal, 157–287 x 96–136 μ, composed of scattered spores interspersed among sterile parenchymatous cells. Spores spherical to oval, 9–13 x 8–11 μ; epispore thin, smooth, light cinnamon-yellow.

On Pontederiaceae:

Monochoria vaginalis Presl

Type locality and host: Bangalore, India, on *Monochoria vaginalis*.

Distribution: Taiwan; also in India.

DOASSANSIA Cornu

Ann. Sci. Nat. VI. 15: 285. 1883.

Sori generally in the leaves, permanently embedded in the host tissues, indehiscent. Spore-ball consisting of a distinct layer of cortex and a central mass of spores. Spores light-colored, of medium size.

Doassansia opaca Setch., Proc. Amer. Acad. 26: 15. 1891.

Sori in the leaves, forming at first yellow but eventually yellow brown, subcircular spots, visible on both surfaces, 3–5 mm. diam. Spore-balls closely compacted in the mesophyll, usually in one layer, each consisting of a central mass of fertile spores invested by an olive brown cortex, subglobose to ellipsoidal, 157–290 x 105–248 μ. Cortical cells elongate and more or less angular, pale olivaceous yellow when isolated, 15–24 x 9–16.5 μ, faintly verruculose. Spores rather loosely compacted, spherical to ellipsoid, mostly somewhat angular, 11–16.5 x 9–12.5 μ; epispore smooth, 1 μ thick, pale yellowish.

On Alismaceae:

Sagittaria trifolia L.

Type locality and host: Massachusetts, United States, on *Sagittaria latifolia* Willd.

Distribution: Taiwan; also in North America.

DOASSANSIOPSIS Dietel

Engl. & Prantl, Nat. Pflanzenfam. I. 1: 21. 1897.

Sori generally in the leaves, permanently embedded in the host tissues, indehiscent. Spore-ball consisting of a cortex, one or more layers of spores and a central mass of parenchymatous cells. Spores usually firmly united, of medium size.

Doassansiopsis horiana (P. Henn.) Shen, Sinensia 4: 319. 1934.

Doassansia horiana P. Henn., in Engl. Bot. Jahrb. 37: 157. 1905.
Doassansiopsis horiana Nishikado, Bericht. Ohara Inst. Landw. Forsch. 7: 419. 1936.

Sori in the leaves and petioles, forming brown pustules which at the advanced stages of development frequently become thickened and raised as hemispherical galls, up to 2.5 cm. in length, causing distortion of the infected parts of the host. Spore-balls densely filling the mesophyll in single layer, subglobose to oval, 77–218 x 67–188 μ, opaque, firm, each consisting of a cortical layer investing a single layer of fertile spores and a mass of parenchymatous cells filling the interior. Cortical cells irregularly arranged in 3–4 layers, polyhedral, subhyaline, 5–7 x 4–5 μ. Parenchymatous cells thin-walled, pale olivaceous, variable in size, up to 21 μ in length. Spores firmly united, elongate and angular, smooth, reddish brown in mass, 10–17 x 7–10.5 μ.

On Alismaceae:

Sagittaria sagittifolia L.

Type locality and host: Tokyo, Japan, on *Sagittaria sagittifolia*.

Distribution: Chekiang, Kwangsi, Szechwan; also in Japan, Russia.

USTILAGINACEAE

Sori usually dehiscent at maturity exposing spore masses. Spore germination usually by means of a transversely septate promycelium which produces terminal and lateral sporidia or promycelial branches. Sporidia frequently function as propagative cells as well as reproductive organs. Conidia are not produced in nature except in a few species in *Ustilago* and *Cintractia*.

USTILAGO (Pers.) Roussel

Fl. Calvados II. 47. 1806.

Sori in various parts of the host. Spore mass dusty at maturity. Spores not aggregated into balls, of small to medium size.

Spores smooth
- Sori destroying the inflorescences
  - Sori whip-like, involving the floral stems
    - Sori under 30 cm. in length — *U. shimadae*
    - Sori exceeding 30 cm. in length — *U. kusanoi*
  - Sori not whip-like, confined to the inflorescences — *U. cynodontis*
- Sori destroying various floral parts
  - Sori confined to the anthers — *U. vaillantii*
  - Sori confined to the ovaries
    - Spores 6–9 μ in length — *U. cynodontis* f. *ovariicola*
    - Spores 7–12 μ in length — *U. crameri*
  - Sori involving the ovaries and the glumes — *U. hordei*
- Sori surrounding the internodes of stems — *U. shiraiana*

Spores variously ornamented but not reticulate
- Sori forming galls

- Sori covered by hispid membranes — *U. crus-galli*
- Sori covered by smooth membranes — *U. maydis*
- Sori not forming galls
  - Sori in various floral parts
    - Sori confined to the ovaries
      - Sori covered by hispid membranes — *U. spherogena*
      - Sori covered by smooth membranes
        - Sori over 3 mm. in width — *U. coicis*
        - Sori under 3 mm. in width
          - Sori over 2 mm. in length
            - Spores chiefly over 10 μ in length
              - Spores with echinulations over 1 μ in length — *U. bothriochloae*
              - Spores with short echinulations — *U. neglecta*
            - Spores under 10 μ in length
              - Spores distinctly echinulate — *U. sparsa*
              - Spores punctate — *U. kenjiana*
          - Sori under 2 mm. in length — *U. spermophora*
    - Sori involving both the ovaries and the glumes
      - Sori usually infecting only the basal parts of the glumes — *U. bullata*
      - Sori usually destroying all the floral parts
        - Spores in germination producing sporidia — *U. avenae*
        - Spores in germination producing mycelial branches — *U. nuda*
  - Sori involving the inflorescences
    - Sori whip-like, very long — *U. scitaminea*
    - Sori not whip-like
      - Sori containing long shreds of host remnants — *U. rabenhorstiana*
      - Sori not containing host remnants — *U. sporoboli-indici*
  - Sori in the vegetative parts of the host
    - Sori forming striae
      - Spores 7–11.5 μ in length — *U. sporoboli-indici*
      - Spores 9–15 μ in length — *U. striiformis*
      - Spores 10.5–20 μ in length — *U. aculeata*
    - Sori not forming striae
      - Sori confined to the leaves — *U. heufleri*
      - Sori in the stems
        - Spores with verrucae in spiral striae
          - Sori encircling the stems — *U. koenigiae*
          - Sori destroying the entire young shoots — *U. ocrearum*
        - Spores verruculose but not striate — *U. esculenta*
- Spores with winged reticulations
  - Spore mass traversed by fine filaments of host tissue — *U. emodensis*
  - Spore mass not mixed with host tissue
    - Sori in the floral parts
      - Sori in the filaments of stamens — *U. filamenticola*
      - Sori in the anthers — *U. violacea*
      - Sori in the ovaries
        - Reticulations of spores under 2 μ in width — *U. warmingii*
        - Reticulations chiefly over 2 μ in width
          - Spore mass brown — *U. anhweiana*
          - Spore mass dark purple
            - Reticulations 2–3.3 μ in width — *U. cordai*
            - Reticulations 3–5 μ in width — *U. reticulata*
    - Sori in the leaves
      - Sori isolated, circular — *U. tuberculiformis*
      - Sori usually confluent, indefinite in shape — *U. warmingii*
    - Sori chiefly in stems and peduncles — *U. nepalensis*

Ustilago aculeata (Ule) Liro, Ann. Acad. Sci. Fenn. A. 17: 66. 1924.

Tilletia aculeata Ule, Abh. Bot. Ver. Prov. Brand. 25: 213. 1884.

Sori in the leaves and leaf sheaths, forming linear striae, often merged and extending the whole length of the leaf, at first subepidermal, lead-colored, later becoming exposed. Spores globose to oval, occasionally ovoid or ellipsoid, 10.5–16.5 μ diam. or 11–20 x 9–15 μ; epispore olive brown, coarsely tuberculate, frequently even appearing incompletely cerebriform.

On Gramineae:

Agropyron sp.

Type locality and host: Berlin, Germany, on *Agropyron repens* Beauv.

Distribution: Kiangsu; also in Russia, Japan, Europe, North America.

Ustilago anhweiana Zundel, Mycologia 35: 167. 1943.

Sori in the ovaries, protected by the floral envelops, ovate, 2–3 mm. diam., forming dusty, "Mikado Brown" (Ridgway) spore masses. Spores globose to ellipsoidal, rarely elongate, 7.5–12 μ diam., pale buff, with pentagonal or hexagonal, purple tinged reticulations of 2–3 μ in width.

On Polygonaceae:

Polygonum sp.

Type locality and host: Chiuhua-shan, Anhwei, on *Polygonum* sp.

Distribution: Known only from the type locality.

Ustilago avenae (Pers.) Rostr., Overs. K. Danske Vid. Selsk. Forh. 13. 1890.

Uredo segetum subsp. *avenae* Pers., Syn. Fung. 224. 1801.

Sori in the spikelets, more or less destroying all the floral parts, 5–10 mm. long, forming dusty, dark brown spore masses. Spores globose to subglobose, occasionally more elongate, yellowish to olivaceous brown, lighter colored on one side, finely echinulate, 6–9 μ in length.

On Gramineae:

Avena fatua L.

Avena sativa L.

Type locality and host: Europe, on *Avena sativa*.

Distribution: Heilungkiang, Hokiang, Hopeh, Hsingan, Kiangsu, Kirin, Liaoning, Nunkiang, Shansi, Sunkiang, Szechwan, Taiwan; also in India, Japan, Philippine Islands, Palestine, Russia, Europe, Africa, America, Australia.

Ustilago bothriochloae Ling, Myc. Papers Imp. Myc. Inst. 11: 4. 1945.

Sori in the ovaries, infecting only occasional ones, inconspicuous, each at first protected by a green host membrane, more or less exposed between the glumes, ovoid to ellipsoidal, 2–3 mm. long. Spores globose to ellipsoidal, 11.5–15.5 x 10–13 μ; epispore deep reddish brown, approximately 1.5 μ thick, distinctly and coarsely echinulate, echinulations up to 1.5 μ long.

On Gramineae:

Bothriochloa pertusa (L.) A. Camus

Type locality and host: Chengtu, Szechwan, on *Bothriochloa pertusa*.

Distribution: Known only from the type locality.

Ustilago bullata Berk., in J. D. Hooker's Fl. Novae-Zealand. 2: 196. 1855.

Ustilago bromivora Fisch. v. Waldh., Bull. Soc. Nat. Mosc. 40: 252. 1867.

Sori in the spikelets, bullate, destroying the ovaries and the basal parts of the

glumes, each enclosed at first by a grayish membrane of host tissue and rather compact, then becoming exposed and pulverulent. Spores chiefly globose to oval, deep olivaceous brown, mostly 7.5–11 μ in length, densely verrucose.

On Gramineae:

Bromus unioloides H. B. K.

Type locality and host: Antarctic Regions, on *Agropyron scabrum* (Lab.) Beauv.

Distribution: Kirin; also in India, Russia, South-Western Asia, Australia, Africa, Europe, North America.

Ustilago coicis Bref., Unters. Gesammtg. Myk. 12: 110. 1895.

Sori in the ovaries, subglobose with tapering apices, partially hidden by the sheaths, each enclosed by a thick brownish membrane of host tissue; spore mass dusty, brownish black. Spores globose to ellipsoid, 7–12 x 6–10.5 μ; epispore reddish brown, minutely echinulate, about 0.7 μ thick.

On Gramineae:

Coix lachryma-jobi L.

Type locality and host: Simla, India, on *Coix lachryma-jobi.*

Distribution: Fukien, Hopeh, Kirin, Szechwan; also in India, Java, Japan.

Ustilago cordai Liro, Ann. Acad. Sci. Fenn. A. 17: 12. 1924.

Ustilago utriculosa Auct.

Ustilago bungeana Yen, Contr. Inst. Bot. Nat. Acad. Peiping 4: 190. 1937.

Ustilago reticulisporus Petr., Meddel. från Göteb. Bot. Trädg. 17: 116. 1947.

Sori in the ovaries, partially enclosed by the perianths, subglobose to ovoid, 2–4 mm. long, forming dark purple spore masses. Spores globose to ellipsoidal, occasionally elongate and irregular, 9–14 μ, rarely up to 16.5 μ long; epispore pale buff to pale vinaceous, with distinct winged reticulations, chiefly 2–3.3 μ wide and 1 μ deep.

On Polygonaceae:

Polygonum barbatum L.

Polygonum barbatum L. var. *gracile* (Danser) Steward

Polygonum bungeanum Turcz.

Polygonum caespitosum Bl.

Polygonum caespitosum Bl. var. *longisetum* (De Bruyn) Steward

Polygonum hydropiper L.

Polygonum hydropiper L. var. *flaccidum* (Meisn.) Steward

Type locality and host: Finland, on *Polygonum hydropiper.*

Distribution: Anhwei, Chekiang, Fukien, Kwangtung, Shansi, Taiwan, Kirin, Liaoning, Inner Mongolia; also in Japan, Palestine, Philippine Islands, Russia, Europe, Australia, North and South America.

Ustilago crameri Koern., in Fckl. Jahrb. Nass. Ver. Nat. 27–28: 11. 1873.

Sori in the ovaries, ovoid, 2–3 mm. long, partially concealed by the glumes. Spores spherical to oval, occasionally elongate and irregular, 7–12 μ long; epispore smooth, orange brown, approximately 0.5 μ thick.

On Gramineae:

Setaria italica Beauv.

Type locality and host: Zurich, Switzerland, on *Setaria italica.*

Distribution: Honan, Hopeh, Sikang, Szechwan, Shantung, Shansi, Taiwan, Antung, Heilungkiang, Hokiang, Kirin, Liaoning, Liaopeh, Sunkiang, Suiyuan, Jehol; also in India, Japan, Russia, Europe, Africa, North America, Australia.

Ustilago crus-galli Tracy & Earle, Bull. Torrey Bot. Club 22: 175. 1895.

Ustilago trichophora (Link) Kunze var. *crus-galli* Lavr., Trav. Inst. Sci. Biol. Tomsk 2: 9. 1936.

Sori infecting the stems near or at the nodes, or at the place of inflorescence involving both stem and leaves, nodular or as a series of gall-like structures, variable in size, 0.5 mm. to several centimeters in length, each covered by a tough hispid membrane which ruptures irregularly revealing a dusty, olive brown spore mass. Spores globose to oval, often oblong, 7.5–10 μ diam. or 7.5–12 x 6.7–9 μ; epispore reddish brown, distinctly echinulate.

On Gramineae:

Echinochloa crus-galli (L.) Beauv.

Type locality and host: Utah, United States, on *Panicum crus-galli* L.

Distribution: Anhwei, Taiwan, Hokiang, Kirin; also in Japan, Russia, India, Australia, Europe, North America.

The collections from China are intermediate between the American collections of this species and *Ustilago holubii* Syd. in the characters of the spores. The latter species has light olivaceous, finely echinulate spores, measuring 6.7–9 μ diam. or 7.5–9.7 x 6–8.2 μ.

Ustilago cynodontis P. Henn., Bull. Herb. Boiss. 1: 114. 1893.

Sori in the inflorescences, elongate, 3–4 cm. long, concealed at an early stage by the enveloping leaf sheaths, but soon naked exposing the black dusty spore masses intermixed with crinkled remnants of the rachis. Spores spherical to subspherical, often oval, 6–9 μ diam.; epispore olivaceous brown, smooth, thin.

On Gramineae:

Cynodon dactylon (L.) Pers.

Type locality and host: Eritrea, East Africa, on *Cynodon dactylon*.

Distribution: Anhwei, Chekiang, Fukien, Honan, Kiangsu, Kwangtung, Kweichow, Taiwan; also in Afghanistan, Burma, India, Indo-China, Japan, Russia, South-Western Asia, Africa, Australia, Europe, North America.

Ustilago cynodontis P. Henn. forma **ovariicola** f. nov.

A specie differt in evolutione in ovariis, glumis intactis.

Differs from the species by the occurrence of sori in the ovaries, with glumes intact.

On Gramineae:

Cynodon dactylon (L.) Pers.

Type locality and host: Amoy, Fukien, on *Cynodon dactylon* (intercepted at Inspection House, Washington, D. C., U. S. A., Jan. 12, 1917, R. K. Beattie).

Distribution: Known only from the type locality.

Ustilago emodensis Berk., in Hooker's Jour. Bot. 3: 202. 1851.

Ustilago treubii Solms Laubach, Ann. Jard. Bot. Buitenz. 6: 79. 1886.
Elateromyces treubii Bub., Arch, Prirodoved. Vyzkum Cech. 15(3): 33. 1912.
Ustilago rosulata Syd., Ann. Myc. 10: 77. 1912.
Farysia emodensis Syd., Ann. Myc. 17: 42. 1919.
Liroa emodensis Cif., Nuovo Giorn. Bot. Ital. n. s. 40: 263. 1933.
Ustilago lycoperdiformis Zundel, Mycologia 36: 402. 1944.

Sori in the flowers, irregularly globoid, up to 7 mm. in diameter, also infecting the stems, causing the formation of stipitate, conical, clustered outgrowths, with pulvinate, often lobate apexes, varying from several millimeters to 1.5 cm. or larger in diameter. Spore mass "Deep Livid Brown" (Ridgway), traversed by profuse, fine filaments of remnant host tissue. Spores globose to ovoid, often angular or oblong, chiefly 6–8.7 x 4.7–7.5 μ, unusually large ones up to 11.5 μ in length; epispore about 1.5 μ

thick, pale yellowish, with extremely fine, light purplish, regular reticulations, approximately 0.7 μ diam., appearing as verrucae under lower magnifications.

On Polygonaceae:

Polygonum chinense L.

Polygonum sp.

Type locality and host: Tonglo, India, on *Polygonum* sp.

Distribution: Kwangsi, Taiwan; also in Ceylon, India, Indo-China, Java, Philippine Islands.

Both the sori and spores of this species are very variable in size. In the type of *U. lycoperdiformis* which is in a very advanced stage of development, the flower-occupying sori are extremely irregular in magnitude; while in certain Philippine collections they are very regular in shape and measure only around 1 mm. in diameter. Unusually large or small spores are often present, with extremes at 3 and 13 μ in length respectively, but the ornamentation of spores always serves as an invariable character.

Ustilago esculenta P. Henn., Hedwigia 34: 10. 1895.

Melanopsichium esculentum Mundk. & Thirumal., Myc. Papers Imp. Myc. Inst. 16: 2. 1946.

Sori in the young stems, causing conspicuous hypertrophy. Spore mass formed in round or elongate cavities in the hypertrophied organ, bounded by the sclerenchyma tissue, deep "Hay's Brown" (Ridgway), at first agglutinate but soon dusty. Spores globose to ellipsoid, 6–10 x 4.6–7 μ; epispore ochraceous brown, verruculose, 1 μ thick.

On Gramineae:

Zizania latifolia (Griseb.) Turcz.

Type locality and host: Hanoi, Indo-China, on *Zizania latifolia.*

Distribution: Chekiang, Fukien, Honan, Hopeh, Hunan, Kiangsu, Kwangsi, Kwangtung, Szechwan, Taiwan; also in India, Indo-China, Japan, Russia, North America.

This fungus destroys only the parenchyma or ground tissue of the host and fails to attack the sclerenchyma and fibro-vascular bundles. It does not cause the formation of any abnormal tissue in the host and the spore mass is dusty at maturity. It appears to be different from *Melanopsichium*, therefore it is retained here in *Ustilago.*

Ustilago filamenticola Ling, Myc. Papers Imp. Myc. Inst. 11: 5. 1945.

Sori in the filaments of the stamens, causing hypertrophy, with ovaries and styles intact, each protected by a thin membrane of host tissue which disintegrates later revealing a dusty "Rood's Brown" (Ridgway) spore mass. Spores globose to oval, 9–13 μ diam.; epispore pale yellowish, with winged penta- or hexagonal reticulations, chiefly 2–3.3 μ wide and 1.5 μ deep.

On Polygonaceae:

Polygonum japonicum Meisn.

Type locality and host: Chengtu, Szechwan, on *Polygonum japonicum.*

Distribution: Known only from the type locality.

Ustilago heufleri Fckl., Jahrb. Nass. Ver. Nat. 23–24: 39. 1870.

Ustilago tulipae Wint., in Rab. Krypt. Fl. 1: 86. 1881.

Sori in the leaves, forming lenticular, convex pustules, 5–12 mm. long, 1–2 mm. wide, covered by the host tissue which later ruptures into a longitudinal slit disclosing a dusty black spore mass. Spores globose to oblong, occasionally ovoid or pyriform, 15–22 x 13.5–17 μ, each loosely invested by a hyaline, somewhat wrinkled envelope; epispore 1.5–2.5 μ thick, light yellow brown, sparsely but very deeply pitted, with pits frequently arranged in irregular striae; endospore with an evident wall, 1–1.5 μ thick, deep cinnamon brown to deep reddish brown.

On Liliaceae:
Tulipa edulis Baker
Type locality and host: Vienna, Austria, on *Tulipa sylvestris* L.
Distribution: Kiangsu; also in Europe, North America.

Ustilago hordei (Pers.) Lagh., Mitt. Badeschen Bot. Ver. 70. 1889.
Uredo segetum subsp. *hordei* Pers., Syn. Fung. 224. 1801.
Ustilago avenae (Pers.) Rostr. var. *levis* Kell. & Swing., Ann. Rep. Kans. Agr. Exp. Sta. 2: 259. 1890.
Ustilago kolleri Wille, Bot. Notiser 10. 1893.
Ustilago levis Magn., Ber. Natur-Wiss.-Mediz. Ver. Innsbruck 21: 22. 1894.

Sori in the spikelets, usually involving the basal parts of the glumes, compact. Spores globose to subglobose, rarely elongate, smooth, light to medium olivaceous brown, lighter colored on one side, 5–9 μ diam., rarely up to 11 μ in length.
On Gramineae:
Avena sativa L.
Hordeum vulgare L.
Type locality and host: Europe, on *Hordeum* sp.
Distribution: Anhwei, Chahar, Chekiang, Fukien, Hokiang, Honan, Hopeh, Hupeh, Jehol, Kansu, Kiangsu, Kwangsi, Kwangtung, Kweichow, Kirin, Ninghsia, Shansi, Shantung, Shensi, Sikang, Suiyuan, Sunkiang, Szechwan, Taiwan, Tsinghai, Yunnan; also in all of the barley and oats growing countries.

Ustilago kenjiana S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 87. 1935.

Sori in ovaries, infecting only a few spikelets in a panicle, ovoid or oval, 3–6 mm. long, similar to healthy seeds in size, each at first covered by a pale brown membrane of host tissue which ruptures later disclosing a dark, dusty spore mass; columella lacking. Spores globose to oval, 4.5–8 μ diam.; epispore olivaceous brown, finely punctate.
On Gramineae:
Sorghum vulgare Pers.
Type locality and host: Kungchulin, Liaoning, on *Sorghum vulgare*.
Distribution: Known only from the type locality.

Ustilago koenigiae Rost., Medd. Grønland 3: 352. 1888.

Sori encircling the stems, forming dark purplish brown spore masses, less than 1 cm. long. Spores variable in shape and size, mostly ellipsoid, often globose, ovoid or irregular, 4.5–8 μ diam., or 5.5–11.4 x 4–7.5 μ, the most elongate up to 15.4 μ long; epispore 0.6–1.2 μ thick, subhyaline to pale yellowish, ornamented with light vinaceous to reddish purple verruculae densely and regularly arranged in spiral striae.
On Polygonaceae:
Polygonum pilosum (Maxim.) Forbes & Hemsl.
Type locality and host: Greenland, on *Koenigia islandica* L.
Distribution: Sikang; also in Greenland, Russia, Europe.
In the type of this species, the verruculate-striae are light vinaceous in color and almost undetectable under a high power lens. The Sikang collection, however, possesses spores with somewhat coarser verruculations which are deep purple and readily detectable. *Ustilago ocreanum* Berk. and *Ustilago piperii* Clint., both occurring on *Polygonum*, are similar to this species in the morphology of spores.

Ustilago kusanoi Syd., Mém. Herb. Boiss. 4: 4. 1900.

Ustilago morobiana Zundel, Mycologia 36: 402. 1944.

Sori in the apical buds, involving both the axes of inflorescences and the floral stems, transforming each into a long, curved whip-like structure, up to 50 cm. or more in length, protected at first by the epidermis which soon flakes away revealing a dusty, dark olive brown spore mass surrounding the remnant main axis. Spores spherical to ellipsoid, 3.6–4.7 μ diam., or 4.3–6 x 3.4–4.5 μ; epispore very thin, light olivaceous brown, smooth.

On Gramineae:

Miscanthus floridulus (Labill) Warb.

Miscanthus sinensis Anderss.

Type locality and host: Musashi, Japan, on *Miscanthus sacchariflorus* (Maxim.) Hack.

Distribution: Chekiang, Fukien, Kiangsu, Kweichow, Taiwan; also in Japan, New Guinea, Russia, Philippine Islands.

A form, which occurs in the ovaries of *Miscanthus sinensis* and converts them into elongate filiform bodies, was described by Y. Ling and Chen (Res. Bull. Inst. Zool. Bot. Fukien Acad. 1: 6. 1945.) as *Ustilago kusanoi* f. *anomala-ovariicola*. Its type has not been examined.

Ustilago maydis (DC.) Corda, Icon. Fung. 5: 3. 1842.

Uredo maydis DC., Fl. Franç. 6: 77. 1815.

Ustilago zeae Ung., Einfl. Bodens 211. 1836.

Sori in various parts of the host, forming irregular galls varying in size, at first covered by white membranes, soon rupturing and revealing brown, dusty spore masses. Spores globose to ellipsoid, or somewhat irregular, prominently echinulate, light olivaceous brown, 8–12 μ diam.

On Gramineae:

Zea mays L.

Type locality and host: France, on *Zea mays*.

Distribution: Chekiang, Fukien, Honan, Hopeh, Hupeh, Kiangsu, Shansi, Sikang, Szechwan, Liaoning, Antung, Kirin, Liaopeh, Sunkiang, Hokiang, Suiyuan, Nunkiang, Heilungkiang, Jehol; also in India, Japan, Malaya, Palestine, Philippine Islands, Russia, Europe, Africa, America, Australia.

Ustilago neglecta Niessl, in Rab. Fungi Eur. 1200. 1868.

Ustilago panici-glauci Wint., in Rab. Krypt. Fl. 1: 97. 1881.

Sori in the ovaries, usually infecting all of the spikelets in a panicle, ovoid, 2–3 mm. long, protected by the glumes. Spores chiefly globose to oval, 9–14 μ long; epispore deep reddish brown, prominently and abundantly echinulate, 0.5 μ thick.

On Gramineae:

Setaria lutescens (Weigel) Hubbard

Setaria viridis Beauv.

Type locality and host: Gratz, Austria, on *Setaria lutescens*.

Distribution: Chekiang, Hainan, Hopeh, Kiangsu, Liaoning, Szechwan, Taiwan; also in India, Indo-China, Japan, Russia, Europe, North and South America.

Ustilago nepalensis Liro, Ann. Acad. Sci. Fenn. A. 17: 184. 1924.

Liroa nepalensis Cif., Fl. Ital. Crypt. I. 17: 247. 1938.

Sphacelotheca nankingensis Zundel, Mycologia 36: 406. 1944.

Sori in the young stems, peduncles, often extending to the basal parts of the flowers, sometimes also in pedicels, from where the infection may spread to the leaves along

midribs; infected tissues somewhat hypertrophied. Spores globose to oval, often oblong to slightly angular, 9.5–14 x 9–13.5 μ; epispore reddish purple, 1.5 μ thick, with fine winged, chiefly hexagonal reticulations, 1.2–2.7 μ wide.

On Polygonaceae:

Polygonum nepalense Meisn.

Type locality and host: Shensi, on *Polygonum nepalense*.

Distribution: Anhwei, Hunan, Shensi; also in India, Japan, Russia.

Ustilago nuda (Jens.) Rostr., Tidsskrift. Landokonomi 8: 745. 1889.

Ustilago segetum var. *nuda* Jens., Jour. Roy. Agr. Soc. England 24 (Ser. 2): 406. 1888.

Ustilago tritici Rostr., Overs. Kong. Danske Vidensk. Selsk. Forh. 15. 1890.

Sori in the spikelets, usually destroying all the floral parts, about 7–12 mm. long, forming olivaceous brown to almost black spore masses loosely adhering to remnant rachis. Spores globose to oval, minutely echinulate, light olivaceous brown, lighter colored and often almost smooth on one side, 5–7 μ diam. or 6.5–9 x 5–6.5 μ.

On Gramineae:

Hordeum vulgare L.

Triticum aestivum L.

Type locality and host: Europe, on *Hordeum* sp.

Distribution: Anhwei, Chekiang, Fukien, Honan, Hopeh, Kiangsi, Kiangsu, Kwangsi, Kwangtung, Shantung, Shansi, Sikang, Szechwan, Taiwan, Yunnan, Jehol, Liaoning, Liaopeh, Kirin, Sunkiang, Hokiang, Nunkiang, Heilungkiang, Hsingan; also in all of the wheat and barley growing countries.

Ustilago ocrearum Berk., in Hookers' Jour. Bot. 6: 207. 1854.

Ustilago caulicola Zundel, Mycologia 34: 123. 1942.

Sphacelotheca smithii Petr., Meddel. från Göteb. Bot. Trädg. 17: 115. 1947.

Sori completely destroying the young shoots or the young axillary branches, extending to over 10 cm. in length, often causing fasciation of the infected parts, occasionally also in the basal parts of the leaves. Spore mass dusty, dark purple brown. Spores variable in shape and size, mostly ellipsoid, often globose, ovoid or irregular, 4.5–8 μ diam., or 5.5–10.5 x 4–7.5 μ, the most elongate rarely up to 13.5 μ long; epispore 0.6–1.2 μ thick, subhyaline to pale yellowish, ornamented with reddish purple verruculae densely and regularly arranged in spiral striae.

On Polygonaceae:

Polygonum campanulatum Hook. f. var. *fulvidum* Hook. f.

Polygonum sp.

Type locality and host: Nangki, East Nepal, on *Polygonum campanulatum*.

Distribution: Sikang; also in Nepal.

Ustilago rabenhorstiana Kuehn, Hedwigia 15: 4. 1876.

Ustilago setariae Rab. ex Fisch. v. Waldh., Aperçu Syst. Ustil. 24. 1877.

Ustilago royleani Syd. & Butl., Ann. Myc. 4:426. 1906.

Ustilago eleusines Syd., Ann. Myc. 27: 241. 1929.

Ustilago belgiana Zundel, Mycologia 36: 401. 1944.

Sori usually involving entire inflorescences, linear-ellipsoidal, 2–5 cm. long, often infecting only the lower parts of inflorescences, leaving the upper parts intact but abortive, at first hidden by the enveloping leaf sheaths, later becoming exposed as dusty, brownish black spore masses, each surrounding a number of elongate remnants of the inflorescence. Spores globose to oval, occasionally somewhat angled, 9–14.5 x 8–12 μ; epispore deep ochraceous brown to deep reddish brown, distinctly echinulate.

On Gramineae:
Digitaria chinensis Hornem.
Digitaria ischaemum (Schreb.) Muhl.
Digitaria sanguinalis (L.) Scop.
Digitaria sanguinalis (L.) Scop. var. *ciliaris* (Retz.) Parl.
Digitaria ternata (Rich.) Stapf
Digitaria sp.
Type locality and host: Europe, on *Panicum sanguinale* L.
Distribution: Anhwei, Hopeh, Hupeh, Kiangsu, Sikang, Szechwan; also in India, Japan, Russia, Africa, Australia, Europe, North and South America.

Ustilago reticulata Liro, Ann. Acad. Sci. Fenn. A. 17: 20. 1924.
Ustilago utriculosa Auct.

Sori in the ovaries, partially enveloped by the perianths, subglobose to ovoid, 2–4 mm. long, forming dark purple spore masses. Spores globose to ellipsoid, 9–14 μ long; epispore deep purplish vinaceous, with prominent winged reticulations, chiefly 3–5 μ wide and 1.5 μ deep.
On Polygonaceae:
Polygonum lapathifolium L.
Polygonum lapathifolium L. var. *lanatum* (Roxb.) Steward.
Polygonum opacum Samuels.
Polygonum viscosum Ham.
Type locality and host: Finland, on *Polygonum tomentosum* Schrank. (= *P. lapathifolium*)
Distribution: Fukien, Kwangsi, Shansi, Sikang, Szechwan, Taiwan; also in India, Japan, Russia, Europe, North America.

Ustilago scitaminea Syd., Ann. Myc. 22: 281. 1924.

Sori in the apical buds, destroying the entire floral stems and transforming each into a curved whip-like growth up to 120 cm. long, partially concealed by the sheath, enclosed in a delicate membrane of host tissue which ruptures later disclosing a dusty, dark brown spore mass. Spores globose to oval, occasionally somewhat irregular, reddish brown, echinulate, 6.5–10 x 6–9 μ.
On Gramineae:
Saccharum officinarum L.
Saccharum sinense Roxb.
Type locality and host: Southern Asia, on *Saccharum officinarum*.
Distribution: Fukien, Hainan, Kwangsi, Kwangtung, Szechwan, Taiwan; also in Burma, India, Indo-China, Japan, Java, Philippine Islands, Russia, Africa, West Indies, South America.

Ustilago shimadae Saw., Taiwan Agr. Res. Inst. Rep. 87: 34. 1943.

Sori in the apical buds, involving both the axes of inflorescences and the floral stems, transforming each into a long, curved flagelliform structure, covered by a whitish delicate membrane of host tissue, approximately 25 cm. long. Spores chiefly globose to subglobose, 4.4–6.5 μ diam.; epispore thin, smooth, light olivaceous brown.
On Gramineae:
An undetermined species of Andropogoneae.
Type locality and host: Taipeh, Taiwan, on Andropogoneae.
Distribution: Known only from the type locality.

Ustilago shiraiana P. Henn., in Engl. Bot. Jahrb. 28: 260. 1900.
Cintractia bambusae Miyabe & Hori in Yoshino, Bot. Mag. Tokyo 19: (199). 1905.

Sori surrounding the internodes of young shoots, forming blackish brown, semi-

agglutinate spore masses, enclosed at first by leaf sheaths, often causing witches-broom effect. Spores spherical to oval, occasionally ovoid, 6–9 μ diam., or 8–10 x 6.5–8 μ; epispore light olivaceous, 0.6–0.8 μ thick, smooth.

On Gramineae:

Phyllostachys congesta Rendle
Phyllostachys makinoi Hayata
Phyllostachys spp.

Type locality and host: Nikko, Japan, on *Bambusa veitchi* Carr.

Distribution: Fukien, Honan, Kiangsi, Kiangsu, Kweichow, Taiwan; also in India, Japan, Russia, North America.

Ustilago sparsa Underw., Bull. Torrey Bot. Club 24: 86. 1897.

Sori in the ovaries, infecting only occasional ones, ovoid, 2–3 mm. long, partially exposed between the spreading glumes, each covered at first by a grayish brown membrane. Spores spherical to oval, often ellipsoid or ovoid, 6–10 μ long; epispore 1 μ thick, clear reddish brown, distinctly echinulate.

On Gramineae:

Dactyloctenium aegypticum (L.) Richt.

Type locality and host: Alabama, United States, on *Dactyloctenium aegypticum*.

Distribution: Taiwan; also in India, North America.

Ustilago spermophora Berk. & Curt. ex de Toni, in Sacc. Syll. Fung. 7: 466. 1888.

Ustilago kusanoana P. Henn., Hedwigia 43: 140. 1904.
Sphacelotheca kusanoana P. Henn., in Engl. Bot. Jahrb. 34: 594. 1905.
Ustilago spermophora Berk. & Curt. var. *orientalis* Yen, Ann. Crypt. Exot. 7: 86. 1934.
Ustilago orientalis Yen, Contr. Inst. Bot. Nat. Acad. Peiping 3: 7. 1935.
Sphacelotheca cheoana Zundel, Mycologia 35: 168. 1943.
Ustilago spermophoroides Y. Ling & Chen, Res. Bull. Inst. Zool. Bot. Fukien Acad. 1: 5. 1945.

Sori in the ovaries, infecting only a few spikelets in a panicle, 0.5–1.5 mm. long, each at first enclosed in a green membrane of host tissue and a delicate inner membrane of fungous tissue. Spores globose to ellipsoid, 7.5–14 x 6–12 μ; epispore olivaceous to reddish brown, minutely to prominently echinulate.

On Gramineae:

Eragrostis cilianensis (All.) Link
Eragrostis ferruginea Beauv.
Eragrostis japonica (Thunb.) Trin.
Eragrostis tenella (L.) Beauv.

Type locality and host: South Carolina, United States, on *Eragrostis cilianensis*.

Distribution: Anhwei, Fukien, Kiangsu, Szechwan; also in India, Japan, Europe, North and South America.

The type collection of this species has minutely echinulate spores measuring 7.4–11.4 x 6.7–9.4 μ. It agrees very well with the type of *U. kusanoana* and certain collections from China. Other collections from China and North America, however, show considerable variation in the degree of echinulation, and color and size of spores. *Ustilago egenula* Syd. & Butl. from India and *Ustilago eragrostidis-japonicana* Zundel from South Africa appear to represent the two extremes of this fluctuating and variable group. The former has minutely echinulate and deep reddish brown spores measuring 9.5–13.5 x 8.7–12 μ; while the latter has distinctly echinulate, light olivaceous brown spores measuring 6.7–8.7 x 6–8.7 μ. The collection on *Eragrostis tenella* from Anhwei has spores similar to *U. egenula* in size and color but with prominent echinulations.

The type of *Ustilago spermophoroides* has not been examined. According to its description, it may be identical with either *U. spermophora* or *U. egenula*.

Ustilago spherogena Burr. ex De T., in Sacc. Syll. Fung. 7: 468. 1888.

Sori in the ovaries, subglobose or ovoid, 2–4 mm. in length, in earlier stages compact and each covered with a greenish tough hispid membrane which ruptures irregularly from the apex disclosing finally a dusty spore mass. Spores globose to oval, occasionally ellipsoid or oblong, 6.5–9 μ diam. or 7–10.5 x 6–9 μ, averaging 8.7 μ in length; epispore light olivaceous brown, sparsely but distinctly echinulate; hyaline immature spores abundant in the interior of the sori.

On Gramineae:

Echinochloa colonum (L.) Link

Echinochloa crus-galli (L.) Beauv.

Echinochloa crus-pavonis (H.B.K.) Schult.

Echinochloa frumentacea Link

Type locality and host: Illinois, United States, on *Panicum crus-galli* L.

Distribution: Fukien, Kiangsu, Kweichow, Szechwan, Taiwan; also in Japan, Russia, South Africa, North and Central America.

The two American collections examined (Ell. & Ev., N. Am. Fungi 1892; Ill. 1882, A. B. Seymour, type ?, in Farl. Herb.) have slightly larger spores than the Chinese and Japanese collections, averaging 9.7 μ in length. *Ustilago trichophora* (Link) Kunze (type in Clint. Herb., Conn.) is similar to this species except possessing ochraceous brown spores measuring 9–10.5 μ diam. or 9–12 x 7–9 μ, with an average of 10.2 μ in length. The type of *Ustilago panici-frumentacei* Bref. has not been seen, but it is doubtful whether it is distinct from this species.

Ustilago sporoboli-indici Ling, Myc. Papers Imp. Myc. Inst. 11: 7. 1945 (Fig. 2,B)

Sori in the leaves, leaf sheaths and stems, forming long or short striae, frequently also destroying partially and deforming the panicles, first covered by the epidermis which ruptures later exposing the dark, pulverulent spore mass. Spores globose to ellipsoid, 7–8.5 μ diam. or 7–11.5 x 5.5–9.5 μ; epispore reddish brown, verruculose.

On Gramineae:

Sporobolus indicus (L.) R. Br.

Type locality and host: Chengtu, Szechwan, on *Sporobolus indicus*.

Distribution: Szechwan; also in Philippine Islands, Africa.

Ustilago striiformis (Westend.) Niessl, Hedwigia 15: 1. 1876.

Uredo striaeformis Westend., Bull. Acad. Roy. Belg. 18: 406. 1851.

Sori in the leaves and leaf sheaths, forming short or long linear striae, at first covered by the epidermis which soon ruptures exposing the dark spore mass, after the dispersal of spores the infected leaves becoming shredded. Spores spherical to ellipsoid, occasionally somewhat irregular, 9–15 x 8–11.5 μ, reddish brown, prominently echinulate.

On Gramineae:

Hierochloa glabra Trin.

Type locality and host: Courtrai, Belgium, on *Holcus lanatus* L.

Distribution: Hopeh; also in India, Japan, Russia, Australia, Europe, North America.

Ustilago tuberculiformis Syd., Ann. Myc. 1: 22. 1903. (Fig. 1,C)

Ustilago foliorum S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 88. 1935.

Sori in the leaves, hypophyllous, circular, 1–2 mm. diam., slightly raised, protected at first by host epidermis, then becoming naked exposing compact, "Prussian Red" (Ridgway) spore masses, causing indefinite, tawny or purplish spots on the upper surface of the leaves. Spores globose to oval, occasionally subangular, 9.4–12.8 x

8.7–11.4 μ; epispore subhyaline to pale yellowish, approximately 1 μ thick, with fine winged reticulations, 1.3–2 μ wide and 0.5–0.7 μ deep.

On Polygonaceae:

Polygonum runcinatum Hamilt. ex D. Don (= *P. morrisonense* Hayata)

Type locality and host: Hupeh, on *Polygonum runcinatum*.

Distribution: Hupeh, Taiwan.

Ustilago vaillantii Tul., Ann. Sci. Nat. III. 7: 90. 1847.

Sori in the anthers, sometimes also in the ovaries, forming dusty "Sepia" (Ridgway) spore masses. Spores variable in shape, chiefly oval, occasionally globose, ovoid to narrowly ellipsoid, 6–12 x 5.5–8 μ; epispore buffy olive, approximately 0.5 μ thick, smooth; endospores indistinctly pitted.

On Liliaceae:

Scilla sinensis (Lour.) Merr. (= *S. chinensis* Benth.)

Type locality and host: Europe, on *Muscari comosum* (L.) Mill.

Distribution: Chekiang; also in Japan, Russia, Persia, Europe, North America.

Ustilago violacea (Pers.) Roussel, Fl. Calvados 47. 1806.

Uredo violacea Pers., Syn. Fung. 225. 1801.

Sori in the hypertrophied anthers, rather inconspicuous, filling each with a purplish spore mass. Spores chiefly globose to oval, occasionally ovoid, oblong or somewhat angular, 5–10.5 μ in length; epispore pale yellowish to pale vinaceous, with violet winged reticulations, 1–2 μ wide and 0.5 μ deep.

On Caryophyllaceae:

Dianthus superbus L.

Silene tatarinowii Regel

Silene tenuis Willd. var. *rubescens* Franch.

Type locality and host: Europe, on *Silene nutans* L.

Distribution: Hopeh, Sikang, Sunkiang; also in Japan, Russia, South-Western Asia, Africa, Europe, North and South America.

The collections on *Dianthus superbus* and *Silene tenuis* var. *rubescens* have spores measuring 7–10.5 μ in length which are larger than that ordinarily described for this species, but approach the size of spores of *Ustilago major* Schroet. It is considered, however, only as the variation of a single species.

Ustilago warmingii Rostr., Bot. Tidsskr. 15: 229. 1886.

Sori in the flowers or forming circular to elongate pustules in the leaves, destroying all the leaf tissues except vascular bundles and epidermis, upon rupture of the epidermis exposing deep brown dusty spore masses. Spores globose or ovoid, often oblong or somewhat angular, 6–10 μ in length; epispore pale yellowish, with violet polygonal winged reticulations, 1–1.8 μ wide and 0.5–0.7 μ deep.

On Polygonaceae:

Rumex aquaticus L.

Type locality and host: Finnmark, Norway, on *Rumex domesticus* L.

Distribution: Hsingan; also in Russia, Europe.

SPHACELOTHECA D. By.

Verg. Morph. Biol. Pilze 187. 1884.

Sori chiefly in the inflorescences, often limited to the ovaries, each provided with a false membrane composed of fungous cells. Spore mass usually dusty at maturity, surrounding one to numerous columellae. Spores not aggregated into balls, developed often in a centripetal manner, of small to medium size.

Sori involving the inflorescences
  Spores surrounding a central columella
    Spores smooth or apparently smooth
      Sori under 2 cm. in length
        Columella filiform, very slender and twistable — *S. apludae*
        Columella not filiform, stiff — *S. anthistiriae*
      Sori exceeding 3 cm. in length
        Spores under 6.5 μ in length — *S. nankinensis*
        Spores chiefly exceeding 6.5 μ in length — *S. rottboelliae*
    Spores punctate, verruculose or echinulate
      Sori long, whip-like, involving the floral stems
        Spores 5–8 μ in length — *S. miscanthi*
        Spores 10–15 μ in length — *S. ophiuri*
      Sori not whip-like, confined only to the inflorescences
        Sori frequently destroying inflorescences only partially — *S. capillipedii*
        Sori usually destroying inflorescences completely
          Columella simple, usually strongly curved — *S. isachnes*
          Columella usually more or less branched, stiff
            Sori chiefly under 1.5 cm. in length — *S. anthistiriae* var. *punctata*
            Sori chiefly over 1.5 cm. in length — *S. andropogonis*
  Spores intermixed with numerous filaments
    Spores smooth to punctate — *S. destruens*
    Spores densely echinulate — *S. reiliana*
Sori confined to the ovaries
  Columella largely composed of fungous tissue
    Spores chiefly 7–11 μ in length — *S. hydropiperis* var. *borealis*
    Spores chiefly 9–14 μ in length — *S. hydropiperis*
  Columella composed of host tissue
    Spores smooth to punctate
      False membrane after rupture usually persistently attached to the sorus — *S. sorghi*
      False membrane after rupture usually disappears
        Columella prominent, exceeding 5 mm. in length — *S. cruenta*
        Columella rather inconspicuous, under 5 mm. in length
          Spores 5.5–9 μ in length — *S. taiana*
          Spores 7–12 μ in length — *S. sacchari*
    Spores verrucose or echinulate
      Sori chiefly under 4 mm. in length
        Spores 6.5–10 μ in length — *S. tanglinensis*
        Spores 9–12 μ in length — *S. tanglinensis* var. *hainanae*
      Sori chiefly exceeding 4 mm. in length
        Spores 5–9 μ in length — *S. sorghi*
        Spores 9–13.5 μ in length — *S. monilifera*
        Spores 10.5–16 μ in length — *S. penniseti-japonica*

Sphacelotheca andropogonis (Opiz) Bub., Arch. Prirodoved. Vyzkum Cech. 15 (3): 25. 1912.

Uredo andropogonis Opiz, Naturalient. 43. 1823–24.
Ustilago ischaemi Fckl., Annal. Soc. Nass. Nat. Scrut. F. 15: 22. 1860.
Sphacelotheca ischaemi Clint., Jour. Myc. 8: 140. 1902.

Sori destroying entire inflorescences, 1.5–3 cm. long, frequently forming aggregated spikelet-like branches which are blended together around the rachis by a wood brown false membrane, upon rupture of the membrane exposing a shortly branched columella surrounded by the dark agglutinate spore mass. Sterile cells of the false membrane hyaline, chiefly globose to ellipsoid, 8.5–22 x 7–17 μ. Spores globose to

oval, 8.5–10 μ diam. or 8–11.5 x 7–10 μ, rarely up to 14 μ long; epispore very finely echinulate, reddish brown.

On Gramineae:

Heteropogon contortus (L.) Roem. & Schultes

Type locality and host: Prague, Czechoslovakia, on *Andropogon ischaemum* L.

Distribution: Szechwan; also in Philippine Islands, Russia, South-Western Asia, Europe, Africa, North and Central America.

Sphacelotheca anthistiriae (Petch) comb. nov.

Ustilago anthistiriae Petch, Ann. Roy. Bot. Gard. Peradeniya 4: 304. 1909.
Cintractia exserta McAlp., Smuts Austral. 169. 1910.
Sphacelotheca exserta Cif., Ann. Myc. 26: 32. 1928.
Sphacelotheca vryburgii Zundel, Mycologia 23: 298. 1931.
Sphacelotheca exserta Yen, Contr. Inst. Bot. Nat. Acad. Peiping 4: 196. 1937.
Ustilago condigna Syd., Ann. Myc. 36: 295. 1938.

Sori in the inflorescences, destroying entire racemes, 4–16 mm. in length, often forming aggregated, spikelet-like branches which are blended together around the rachis, each enclosed at first in a brown false membrane which flakes away disclosing a black, agglutinate spore mass surrounding a central, frequently branched columella; sterile cells of the membrane globose to oval, thin-walled, hyaline, 7.5–16.5 x 6–16 μ. Spores chiefly globose to broadly oval, often compressed, 6–8.7 μ diam. or 6.5–10 x 5.4–8.7 μ, mostly 6.7–8.7 μ in length; epispore smooth, 0.5 μ thick, light to medium yellowish brown.

On Gramineae:

Themeda triandra Forsk.

Type locality and host: Peradeniya, Ceylon, on *Themeda tremula* (Nees) Hack.

Distribution: Honan; also in Ceylon, Australia, Africa.

The sole collection from Honan differs from the type and all other specimens from Australia and Africa available for examination in having smaller spores which are 5.4–8 x 4.5–7.5 μ.

Sphacelotheca anthistiriae (Petch) Ling var. **punctata** var. nov.

A specie differt in sporis minute punctulatis, majoribus, magnitudine variabilibus, 5.5–11.4 x 6.7–10 μ, praecipue 7.5–8.8 μ longis.

Differs from the species in the spores being finely punctate, averaging larger but more variable in size, measuring 5.5–11.4 x 6.7–10 μ, mostly 7.5–8.8 μ long.

On Gramineae:

Themeda triandra Forsk.

Type locality and host: Chengtu, Szechwan, on *Themeda triandra* (Nov. 1947, K. R. Lin).

Distribution: Kiangsu, Szechwan.

Sphacelotheca apludae (Syd.) Pavgi & Mundk., Indian Phytopath. 1: 110. 1948.

Ustilago apludae Syd., Ann. Myc. 17: 141. 1919.

Sori in the racemes, concealed by the spathes, 4–7 mm. long, 1 mm. wide, tapering at both ends, each enclosed at first by a thin false membrane composed of hyaline, thin-walled, subglobose to oblong sterile cells, 6–10.5 x 5–10 μ; columella filiform, single, often forked at the apex, 1–2 cm. long, protruding beyond the sorus. Spores globose to oval, 4.7–7.5 x 4.5–6.7 μ; epispore olivaceous brown, smooth.

On Gramineae:

Apluda mutica L. var. *aristata* Hack.

Type locality and host: Kumaon, Himalayas, India, on *Apluda mutica* var. *aristata*.

Distribution: Kwangtung; also in India.

The type collection of this species from India has spores slightly larger than those of the Kwangtung collection, measuring 6–8 μ in diameter.

Sphacelotheca capillipedii Ling, Myc. Papers Imp. Myc. Inst. 11: 8. 1945.

Sorosporium andropogonis-micranthi Y. Ling & Chen, Res. Bull. Inst. Zool. Bot. Fukien Acad. 1: 21. 1945.

Sori either involving entire inflorescences, or destroying only certain branches or branchlets in a panicle and leaving remaining parts intact but abortive, concealed at first by the leaf sheaths, later protruding, each enclosed by a deep livid brown false membrane which dehisces irregularly revealing a dark brown, agglutinate spore mass adhering to a branched columella. Sterile cells of the false membrane hyaline, globose or angular, 5.5–11 μ in length. Spores agglutinated into balls at an early stage, chiefly globose to subglobose, 7–11 μ, mostly 8.5–9.5 μ diam.; epispore thin, light smoky brown, finely punctate.

On Gramineae:

Capillipedium parviflorum (R. Br.) Stapf

Type locality and host: Chengtu, Szechwan, on *Capillipedium parviflorum*.

Distribution: Fukien, Szechwan.

Sphacelotheca cruenta (Kuehn) A. A. Potter, Phytopath. 2: 98. 1912.

Ustilago cruenta Kühn, Hamburg. Gart. Blumenzeitg. 28: 178. 1872.

Sori in the ovaries, often also involving the floral bracts, ovoid-oblong, up to 1 cm. or more in length, each covered by a delicate false membrane which flakes away early revealing a dark brown spore mass surrounding a prominent, pointed, usually curved, central columella; sterile cells of the membrane breaking up into groups, hyaline, subglobose to ellipsoidal, 7.5–16.5 x 5.5–13.5 μ. Spores globose to oval, chiefly 5.5–9 μ long, punctate, reddish brown.

On Gramineae:

Sorghum vulgare Pers.

Type locality and host: Halle, Germany, on *Sorghum vulgare*.

Distribution: Anhwei, Honan, Hopeh, Hupeh, Kiangsu, Shansi, Taiwan, Yunnan, Liaoning, Antung, Kirin, Liaopeh, Sunkiang, Hokiang, Nunkiang, Heilungkiang, Jehol; also in India, Indo-China, Iran, Japan, Russia, Africa, America, Europe.

Sphacelotheca destruens (Schlecht.) Stevenson & A. G. Johnson, Phytopath. 34: 613. 1944.

Caeoma destruens Schlecht., Fl. Berol. 2: 130. 1824.

Ustilago panici-miliacei Wint., in Rab. Krypt. Fl. 1: 89. 1884.

Sorosporium panici-miliacei Tak., Bot. Mag. Tokyo 16: (253). 1902.

Sorosporium manchuricum S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 93. 1935.

Sphacelotheca lioui Yen, Contr. Inst. Bot. Nat. Acad. Peiping 4: 193. 1937.

Sori destroying the inflorescences, narrowly ellipsoidal, concealed at first by the leaf sheaths, later becoming partially exposed, about 3–5 cm. long, each enclosed by a whitish false membrane which gradually flakes away disclosing a dusty dark spore mass intermixed with numerous strands of remnant host tissue. Spores often loosely united at an early stage, globose to oval, occasionally oblong, chiefly 6.5–10 μ in length; epispore ochraceous brown, approximately 0.5 μ thick, smooth to finely punctate.

On Gramineae:

Panicum miliaceum L.

Type locality and host: Europe, on *Panicum miliaceum*.

Distribution: Antung, Chahar, Jehol, Kansu, Kirin, Liaoning, Shansi, Shensi, Suiyuan, Sunkiang; also in India, Japan, Philippine Islands, Russia, Australia, Europe, North America.

Sphacelotheca hydropiperis (Schum.) D. By., Verg. Morph. Biol. Pilze 187. 1884.

Uredo hydropiperis Schum., Enum. Pl. Saell. 2: 234. 1803.

Sphacelotheca polygoni-senticosi Miyabe & Tak. apud S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 90. 1935.

Sphacelotheca borealis Schellenb. var. *chinensis* Zundel, Mycologia 36: 404. 1944.

Sori in the ovaries, cylindrical, 3–7 mm. in length, protected by the floral envelopes at base, each enclosed at first in a grayish, rather thick false membrane which dehisces from the apex revealing a purplish-black spore mass surrounding a central prominent columella. Sterile cells besides forming the membrane also constituting the essential parts of the columella, hyaline, thick-walled, globose to ellipsoid, 7–20 μ in length. Spores light to deep reddish purple, chiefly globose to subglobose, occasionally oval or somewhat angular, densely verruculose, 8–17.5 μ, mostly 9–14 μ in length.

On Polygonaceae:

Polygonum caespitosum Bl.

Polygonum caespitosum Bl. var. *longisetum* (De Bruyn) Steward

Polygonum hydropiper L.

Polygonum nummularifolium Meisn.

Polygonum sagittatum L.

Polygonum sagittifolium Levl. & Van.

Polygonum senticosum (Meisn.) Fr. & Sav.

Polygonum strindbergii Schuster

Type locality and host: Europe, on *Polygonum hydropiper*.

Distribution: Anhwei, Fukien, Hunan, Kirin, Sikang, Taiwan, Yunnan; also in Ceylon, India, Java, Russia, Philippine Islands, Australia, Europe, America.

Sphacelotheca hydropiperis (Schum.) D. By. var. **borealis** Clint., Proc. Bost. Soc. Nat. Hist. 31: 395. 1904.

Sphacelotheca borealis Schellenb., Ann. Myc. 5: 386. 1907.

Differs from the species chiefly in the smaller spores which measure 7–11 μ in length.

On Polygonaceae:

Polygonum bistorta L.

Type locality and host: Washington, United States, on *Polygonum bistortoides* Pursh.

Distribution: Sunkiang; also in Russia, Europe, North America.

Sphacelotheca isachnes (Syd.) Ling, Mycologia 41: 262. 1949.

Ustilago isachnes Syd., Ann. Myc. 12: 77. 1912.

Ustilago isachnes Saw., Taiwan Agr. Res. Inst. Rep. 87: 33. 1943.

Sori in the inflorescences, linear, 1–2 cm. long, concealed by the sheaths, becoming partially exposed later, each enclosed at first in a light brownish false membrane which flakes away revealing a black dusty spore mass surrounding a simple, frequently curved columella; sterile cells of the false membrane hyaline, thin-walled, subglobose to oblong, 6–15 x 7.5–10.5 μ. Spores chiefly globose to oval, 9–14 μ diam. or 10–16.5 x 8.5–13.5 μ; epispore reddish brown, 0.7 μ thick, densely verruculose.

On Gramineae:

Isachne globosa (Thunb.) Kuntze

Type locality and host: Manila, Philippine Islands, on *Isachne miliacea* Roth.

Distribution: Taiwan; also in Philippine Islands.

Sphacelotheca miscanthi Yen, Contr. Bot. Nat. Acad. Peiping 4: 192. 1937.

Sori in the apical buds, each involving an entire floral stem and transforming it into a curved whip-like structure, up to 50 cm. or more in length, first enclosed by the epidermis of the host and a thin false membrane, upon the rupture of both and

the scattering of the dusty spore mass disclosing the remnant main axis. Sterile cells of the false membrane hyaline, chiefly cubical or oblong, 6–13.5 x 4–9 μ, occasionally subglobose, 9–12 μ diam. Spores chiefly spherical to oval, 5.4–8 μ in length; epispore deep reddish brown, punctate to indistinctly verruculose.

On Gramineae:

Miscanthus anomala Steud.

Miscanthus sacchariflorus (Maxim.) Hack.

Type locality and host: Chefoo, Shantung, on *Miscanthus anomala*.

Distribution: Shantung, Szechwan.

Sphacelotheca monilifera (Ell. & Ev.) Clint., Jour. Myc. 8: 141. 1902.

Ustilago monilifera Ell. & Ev., Bull. Torrey Bot. Club 22: 362. 1895.

Sori in the ovaries, infecting all the spikelets in a raceme, elongate, 4–7 mm. long, partially concealed by the glumes, each enclosed by a brown false membrane which later ruptures irregularly revealing a semi-agglutinate, dark spore mass surrounding a well-developed simple columella; sterile cells of the false membrane firmly bound together, cubical, subglobose or oblong, subhyaline, 7.5–15 x 6–12 μ. Spores globose to oval, 9–13.5 μ long; epispore 1 μ thick, reddish brown to deep reddish brown, finely but abundantly echinulate.

On Gramineae:

Heteropogon contortus (L.) Beauv.

Type locality and host: Arizona, United States, on *Heteropogon contortus*.

Distribution: Yunnan; also in Ceylon, India, Africa, North and Central America.

Sphacelotheca nankinensis Zundel, Mycologia 31: 587. 1939.

Sori involving entire inflorescences and floral stems, linear, exceeding 10 cm. in length, with lower parts concealed by the sheaths, at first each enclosed by the epidermis and a delicate, thin false membrane composed of hyaline, subglobose to ellipsoid sterile cells, 9–18 μ long, upon rupture of the membrane and dispersal of the dark reddish brown spore mass exposing a central, simple columella. Spores globose to ellipsoid, 4.3–6.5 x 4–5.5 μ; epispore thin, smooth, light olivaceous brown.

On Gramineae:

Paspalum ? orbiculare Forst.

Type locality and host: Nanking, Kiangsu, on *Paspalum ? orbiculare*.

Distribution: Known only from the type locality.

Sphacelotheca ophiuri (P. Henn.) Ling, Sydowia 3: 127. 1949. (Fig. 2,C)

Ustilago ophiuri P. Henn., in O. Warburg's Monsunia 1: 1. 1899.

Ustilago flagellata Syd., Ann. Myc. 9: 144. 1911.

Sphacelotheca flagellata Zundel, Bothalia 3: 301. 1938.

Sphacelotheca ophiuri-monostachydis Tai apud Ling, Myc. Papers Imp. Myc. Inst. 11: 8. 1945.

Sori culmicolous, destroying entirely or partially the inflorescences, transforming each into a whip-like structure, up to 10 cm. in length, covered at first by a rather thick, brownish membrane consisting of globoid and hyaline cells, 7–15 μ diam., finally naked and exposing the dark semi-agglutinate spore mass. Spores globose to oval, sometimes elongate or angular, 10–15 x 9–12 μ; epispore smoky reddish brown, densely verruculose, approximately 1 μ thick.

On Gramineae:

Ophiurus monostachys J. S. Presl.

Type locality and host: Java, on *Ophiurus exaltatus* (L.) Kuntze.

Distribution: Yunnan; also in India, Java, Philippine Islands, South Africa.

Sphacelotheca penniseti-japonici (P. Henn.) S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 91. 1935.

Ustilago penniseti Rab. var. *tokinensis* Pat., Jour. de Bot. 4: 57. 1890.
Ustilago penniseti-japonici P. Henn., Hedwigia 43: 140. 1904.

Sori in the ovaries, infecting all the spikelets in a panicle, elongate-ellipsoidal, 5–8 mm. long, extending beyond the enveloping glumes, each with a pallid false membrane rupturing from the apex to disclose 1–4 filaments surrounded by a semi-agglutinate black spore mass; sterile cells of the false membrane hyaline, oblong, 9–24 x 3–4.5 μ, firmly united into long chains. Spores globose to subglobose, occasionally slightly angular, 10.5–16 μ long; epispore deep cinnamon brown, densely verrucose.

On Gramineae:

Pennisetum alopecuroides (L.) Spreng. (= *P. compressum* R. Br., *P. japonicum* Trin.)

Type locality and host: Tokyo, Japan, on *Pennisetum japonicum*.

Distribution: Anhwei, Chekiang, Fukien, Hainan, Hunan, Hupeh, Kiangsu, Kweichow, Szechwan; also in Indo-China, Japan, North America.

Sphacelotheca reiliana (Kuehn) Clint., Jour. Myc. 8: 141. 1902.

Ustilago reiliana Kuehn, in Rab. Fungi Eur. 1998. 1875.
Sorosporium reilianum McAlp., Smuts Austral. 181. 1910.

Sori destroying the inflorescences, very prominent, each enclosed at first in a white false membrane which soon disintegrates disclosing a dusty, dark brown spore mass intermixed with numerous long shredded remnants of host tissue; sterile cells after the decomposition of the membrane scattered throughout the spore mass in groups, subhyaline, globose to oblong, 7–16 μ in length. Spores often loosely united, opaque reddish brown, densely echinulate, globose to subglobose, occasionally ovoid or somewhat angular, 8–15 μ in length.

On Gramineae:

Sorghum vulgare Pers.
Zea mays L.

Type locality and host: Cairo, Egypt, on *Sorghum vulgare*.

Distribution: Chekiang, Honan, Hopeh, Kiangsu, Kweichow, Shansi, Sikang, Szechwan, Taiwan, Liaoning, Antung, Kirin, Liaopeh, Suiyuan, Sunkiang, Hokiang, Nunkiang, Heilungkiang, Jehol; also in Burma, India, Indonesia, Japan, Russia, Palestine, Philippine Islands, Africa, Australia, America, Europe.

Sphacelotheca rottboelliae (Syd. & Butl.) Mundk., Trans. Brit. Myc. Soc. 23: 111. 1939.

Ustilago rottboelliae Syd. & Butl., Ann. Myc. 5: 486. 1907.
Cintractia densa McAlp., Smuts Austral. 168. 1910.
Ustilago rottboelliae Miyake, Bot. Mag. Tokyo 27: 42. 1913.
Sphacelotheca densa Cif., Ann. Myc. 26: 32. 1928.

Sori destroying entirely or partially the inflorescences, up to 6 cm. long, each at first covered by a brownish false membrane composed of hyaline, globoid or oblong sterile cells, upon rupture of the false membrane and dispersal of the dark spore mass leaving behind a curved rachis. Spores spherical to oval, rarely oblong, 6–8.5 μ long; epispore light olive brown, thin, smooth or very faintly punctate.

On Gramineae:

Manisuris compressa (L. f.) Kuntze (= *Rottboellia compressa* L. f., *Hemarthria compressa* R. Br.)

Type locality and host: Pusa, India, on *Rottboellia compressa*.

Distribution: Hupeh, Szechwan; also in India, Japan, Australia, South Africa.

Sphacelotheca sacchari (Rab.) Cif., Fl. Ital. Crypt. I. 17: 262. 1938.

Ustilago sacchari Rab., Sitzungsber. Naturwiss. Ges. Isis 4: 227. 1870.
Ustilago sacchari-ciliaris Bref., Unters. Gesammtg. Myk. 12: 109. 1895.
Ustilago courtoisi Cif., Ann. Myc. 29: 71. 1931.
Sphacelotheca schweinfurthiana (Thuem.) Sacc. var. *minor* Zundel, Mycologia 35: 168. 1943.
Sphacelotheca sacchari Y. Ling & Chen. Res. Bull. Inst. Zool. Bot. Fukien Acad. 1: 11. 1945.

Sori in the ovaries, destroying all the spikelets in a panicle, 3–5 mm. long, partially exposed between the spreading glumes, each enclosed at first by a brownish false membrane which soon flakes away revealing a dusty spore mass surrounding a simple, well-developed, frequently somewhat curved columella; sterile cells of the false membrane hyaline, subglobose to ellipsoid, or cubical, 9–19.5 x 7.5–13.5 μ. Spores chiefly globose to oval, 7–12 μ in length; epispore ochraceous brown, finely punctate, 0.5 μ thick.

On Gramineae:
Saccharum arundinaceum Retz.
Saccharum sp.

Type locality and host: Marasch, Iran, on *Saccharum ravennae* (L.) Murr.

Distribution: Chekiang, Fukien, Hainan, Kiangsu, Kwangsi, Szechwan; also in Burma, India, Java, Malaya, Iran, Europe.

Sphacelotheca sorghi (Link) Clint., Jour. Myc. 8: 140. 1902.

Sporisorium sorghi Link, in Willd. Sp. Pl. 6 (2): 86. 1825.
Ustilago sorghi Pass. apud Thuem., Hedwigia 12: 114. 1873.
Ustilago sorghicola Speg., Anal. Mus. Nac. Buenos Aires III. 1: 58. 1902.
Ustilago bulgarica Bub., Zeitsch. Landwirtsch. Vers. Oesterr. 53. 1910.
Sphacelotheca sorghicola Zundel, Mycologia 22: 131. 1930.

Sori in the ovaries, cylindrical to subconical, 3–7 mm. long, each enclosed at first by a tough and brown, or light gray and thin false membrane which is usually composed of the prosenchymatous tissue, and rather persistent even after rupture; spore mass deep reddish brown, surrounding a short, central, simple columella. Spores light olivaceous brown to reddish brown, globose to oval, occasionally ovoid, 4.7–9 μ, mostly 5–7 μ in length, punctate to finely echinulate.

On Gramineae:
Sorghum vulgare Pers.

Type locality and host: Egypt, on *Sorghum vulgare*.

Distribution: Honan, Hopeh, Taiwan, Shansi, Suiyuan, Liaoning, Liaopeh, Kirin; also in Afghanistan, Burma, Ceylon, India, Indo-China, Japan, Philippine Islands, Russia, Africa, America, Europe.

Sphacelotheca taiana (Syd.) Ling, Myc. Papers Imp. Myc. Inst. 11: 9. 1945.

Ustilago taiana Syd., Ann. Myc. 27: 421. 1929.

Sori in the ovaries, 3–4 mm. long, partially exposed between the spreading glumes, each enclosed at first by a thin, grayish false membrane which soon disintegrates into hyaline, globose to cubical cells, 6.5–12 x 4.5–10.5 μ; columella simple, inconspicuous. Spores chiefly globose to subglobose, occasionally ovoid or ellipsoid, 5.4–7 μ diam. or 6.7–9 x 5–7 μ; epispore light to medium ochraceous brown, 0.5 μ thick, smooth.

On Gramineae:
Sorghum nitidum (Vahl.) Pers.

Type locality and host: Nanking, Kiangsu, on *Sorghum nitidum*.

Distribution: Known only from the type locality.

Sphacelotheca tanglinensis (Tracy & Earle) Zundel, Mycologia 36: 406. 1944.

Ustilago tonglinensis Tracy & Earle, Bull. Torrey Bot. Club 22: 175. 1895.
Ustilago arthraxonis Pat., Jour. de Bot. 11: 346. 1897.
Ustilago ischaemi-akoenses Saw., Taiwan Agr. Res. Inst. Rep. 87: 33. 1944.
Sphacelotheca tonglinensis Y. Ling & Chen, Res. Bull. Inst. Zool. Bot. Fukien Acad. 1:10. 1945.

Sori in the ovaries, infecting all the florets in a raceme, 3–4 mm. long, concealed by the glumes but later protruding, each covered by a pallid false membrane which ruptures at maturity revealing a dark dusty spore mass surrounding a simple central columella; sterile cells of false membrane subglobose, oval or angular, chiefly in chains, 7.5–20 x 6.7–13 μ. Spores globose, subglobose or ellipsoid, 9.5–11.5 μ diam., or 9–12 x 8.7–10 μ; epispore ochraceous brown to reddish brown, distinctly echinulate.

On Gramineae:
Ischaemum aristatum L.
Ischaemum ciliare Retz.
Ischaemum ciliare Retz. var. *genuinum* Hack.

Type locality and host: Tanglin, Singapore, on *Ischaemum ciliare*.

Distribution: Fukien, Hainan, Kwangtung, Taiwan; also in Indo-China, India, Ceylon, Malay States, Philippine Islands, Java.

The collections on *Ischaemum aristatum* usually have slightly smaller and darker spores than those on *I. ciliare*.

Sphacelotheca tanglinensis (Tracy & Earle) Zundel var. **hainanae** (Zundel) comb. nov.

Sphacelotheca hainanae Zundel, Mycologia 31: 585. 1939.

Differs from the species in the smaller spores which measure 6.5–10 μ diam.

On Gramineae:
Ischaemum rugosum Salisb.

Type locality and host: Kachek, Hainan, on *Ischaemum rugosum*.

Distribution: Known only from the type locality.

CINTRACTIA Cornu

Ann. Sci. Nat. VI. 15: 279. 1883.

Sori in various parts of the host, usually enclosed by membranes of fungus tissue. Spore mass compact and firmly agglutinated, developed in a centripetal manner, often with outer parts becoming pulverulent at later stages but its interior remaining firm and immature. Spores not aggregated into balls, usually dark-colored, of medium to large size.

Spores smooth to indistinctly pitted	
Spores 9–14 μ in length	*C. limitata*
Spores 12–17 μ in length	*C. axicola*
Spores 15–21 μ in length	*C. elynae*
Spores verrucose to tuberculate	
Sori surrounding the peduncles or stems	*C. scleriae*
Sori in the ovaries	
Spores usually strongly angular	*C. caricis*
Spores usually spherical to oval	
Spores 16–22.5 μ in length	*C. subinclusa*
Spores 9.5–14.5 μ in length	*C. fimbristylis-miliaceae*

Cintractia axicola (Berk.) Cornu, Ann. Sci. Nat. Bot. VI. 15: 279. 1883.

Ustilago axicola Berk., Ann. Mag. Nat. Hist. II. 9: 200. 1852.
Ustilago peribebuyensis Speg., Anal. Soc. Cien. Argent. 17: 89. 1884.
Cintractia peribebuyensis Speg., Anal. Soc. Cien. Argent. 26: 11. 1888.

Cintractia fimbristylis-kagiensis Saw., Dept. Agr. Gov't. Res. Inst. Formosa Rep. 2: 79. 1922.
Cintractia peribebuyensis Saw., Dept. Agr. Gov't. Res. Inst. Formosa Rep. 2: 80. 1922.
Cintractia suedae Saw., Dept. Agr. Gov't. Res. Inst. Formosa Rep. 2: 81. 1922.
Cintractia mundkuri Chowdhury, Indian Jour. Agr. Sci. 14: 231. 1944.
Cintractia fimbristylis-kagiensis Saw. var. *fukiensis* Y. Ling & Chen, Res. Bull. Inst. Zool. Bot. Fukien Acad. 1: 17. 1945.
Cintractia pilulifera Y. Ling & Chen, Res. Bull. Inst. Zool. Bot. Fukien Acad. 1: 17. 1945.
Cintractia peribebuyensis Speg. var. *major* Pavgi & Mundk., Indian Phytopath. 1: 109. 1948.

Sori at the base of primary or auxiliary rays, less often in the ovaries, globoid to oblong, 1–4 mm. in length, at first each covered by a whitish false membrane which soon disappears exposing the black, agglutinate, compact spore mass. Spores when mature medium to deep reddish brown, often with smoky tint, globose to oval, occasionally oblong or subangular, sometimes laterally compressed, smooth to indistinctly pitted, or faintly ornamented with short, fine, sinuous striae, 12–17 x 9–15.5 μ, epispore 1–1.5 μ thick.

On Cyperaceae:
Fimbristylis annua (All.) Roem. & Schult. (= *F. diphylla* Vahl.)
Fimbristylis annua (All.) Roem. & Schult. var. *pluricostata* Clarke
Fimbristylis kagiensis Hayata
Fimbristylis schoenoides Vahl.

Type locality and host: Dominican Republic, on *Fimbristylis* sp.

Distribution: Fukien, Kiangsi, Kwangtung, Kweichow, Szechwan, Taiwan; also in Ceylon, India, Indo-China, Philippine Islands, Australia, America.

Cintractia caricis (Pers.) Magn., Abh. Bot. Ver. Prov. Brand. 37: 79. 1896.

Uredo caricis Pers., Syn. Fung. 225. 1801.

Sori in the ovaries, subgloboid, 2–3 mm. diam., partially concealed by the perigyniums, at first each enclosed in a white false membrane which soon flakes away disclosing a black, firmly agglutinated mass of spores. Spores dark reddish brown, subopaque, strongly polyhedral, often with hyaline fragments still attached, verrucose, 16.5–27 x 10.5–19.5 μ, epispore 1.5–2.5 μ thick, unevenly thickened.

On Cyperaceae:
Carex capilliformis Franch.
Carex capilliformis Franch. var. *major* Kuekenth.
Carex laticeps C. B. Clarke

Type locality and host: Europe, on *Carex pilulifera* L.

Distribution: Kiangsu, Shensi; also in India, Japan, Russia, Europe, North America.

Cintractia elynae Syd., Ann. Myc. 22: 289. 1924.

Cintractia hyperborea Cif., Ann. Myc. 29: 64. 1931.
Cintractia chinensis Yen, Contr. Inst. Bot. Nat. Acad. Peiping 3: 41. 1935.

Sori in the ovaries, subgloboid, 3–4 mm. diam., each enclosed at first in a white false membrane that soon flakes away disclosing a black, firmly agglutinated spore mass. Spores dark reddish brown, spherical to oval, occasionally oblong or slightly angular, 14.5–21 μ in length, smooth to indistinctly pitted, epispore 1.5–2 μ thick.

On Cyperaceae:
Kobresia scirpina Willd. (= *Elyna spicata* Schrad.)

Type locality and host: Switzerland, on *Elyna spicata*.

Distribution: Chahar; also in India, Russia, Europe, North America.

Cintractia fimbristylis-miliaceae (P. Henn.) S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 92. 1935.

Ustilago fimbristylis-miliaceae P. Henn., in Engl. Bot. Jahrb. 37: 156. 1905.
Cintractia pulchra S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 92. 1935.

Sori in the ovaries, forming globoid, black, compact spore masses, 0.5–1.5 mm. in diameter, each covered at an early stage by a whitish false membrane. Spores when mature yellowish brown, spherical to oval, occasionally subangular, densely verruculose, 9.5–14.5 μ in length, epispore 0.5–1 μ thick.

On Cyperaceae:
Fimbristylis miliacea Vahl.
Type locality and host: Yukatabara, Japan, on *Fimbristylis miliacea.*
Distribution: Fukien; also in Japan, Mexico.

Cintractia limitata Clint., Proc. Bost. Soc. Nat. Hist. 31: 399. 1904.

Cintractia axicola (Berk.) Cornu var. *minor* Clint., Jour. Myc. 8: 143. 1902.
Cintractia togoensis P. Henn., in Engl. Bot. Jahrb. 38: 119. 1905.
Cintractia congensis P. Henn., Ann. Mus. Congo Bot. V. 2: 87. 1907.
Cintractia cyperi-polystachyi P. Henn., Philipp. Jour. Sci. C. 3: 41. 1908.
Cintractia minor Jacks., Mycologia 12: 153. 1920.
Ustilago chaconensis Hirschh., Not. Mus. La Plata 6: 479. 1941.
Ustilago mariscana Zundel, Mycologia 35: 165. 1943.
Cintractia distans Mundk., Indian Jour. Agr. Sci. 14: 50. 1944.

Sori at the base of primary or auxiliary rays, cylindrical, forming black, agglutinate spore masses surrounding the branches, extending up to 1 cm. in length and 7 mm. in diameter, each covered at first by a whitish false membrane which soon disintegrates; often also infecting the ovaries, each forming a globoid black spore mass surrounding a rudimentary columella, 1–2 mm. in diameter, agglutinate at earlier stages, becoming rather dusty, exposed between the spreading glumes, and often spreading to adhere to the glumes and other floral parts. Spores when mature ochraceous brown to deep reddish brown, often with smoky tint, spherical to oval, occasionally subangular, frequently laterally compressed, 9–14.5 x 7.5–13 μ; epispore smooth, 1 μ or less thick.

On Cyperaceae:
Cyperus compressus L.
Cyperus distans L.
Cyperus malaccensis Roxb.
Type locality and host: Puerto Rico, on *Cyperus ligularis* L.
Distribution: Taiwan; also in Ceylon, India, Philippine Islands, Africa, America.

Cintractia scleriae (DC.) Ling, Mycologia 43: 314. 1951.

Uredo scleriae DC. in Poiret, Encycl. Meth. Bot. 8: 879. 1808.
Ustilago ? scleriae Tul., Ann. Sci. Nat. Bot. III. 7: 89. 1847.
Cintractia javanica Racib., Bull. Intern. Acad. Sci. Krakow 1909: 351. 1909.
Cintractia albida S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 93. 1935.

Sori surrounding the pedicels and the branches of the inflorescence, oblong, occasionally oval or even subgloboid, extending up to 3.5 cm. in length, 2.5–4 mm. in diameter, each covered at first by a thick white false membrane enclosing a black, firmly agglutinated spore-mass; infection rarely spreading onto the scales of the rudimentary abortive inflorescences which are invariably present in the infected plants. Spores ochraceous brown, chiefly globose to oval, often cupped at one side, 12–16.5 μ, occasionally up to 18 μ in length, prominently verrucose, verrucae rarely confluent into short, irregular striae or cerebriform; epispore 1–1.5 μ thick; immature spores invariably present in the inner parts of the sorus.

On Cyperaceae:
Rhynchospora corymbosa (L.) Britt.

Type locality and host: Cayenne, French Guiana, on *Rhynchospora* sp.
Distribution: Taiwan; also in Ceylon, Indo-China, Indonesia, Philippine Islands, Africa, Central and South America.

Cintractia subinclusa (Koern.) Magn., Abh. Bot. Ver. Prov. Brand. 37: 79. 1896.
Ustilago subinclusa Koern., Hedwigia 13: 159. 1874.

Sori in the ovaries, subgloboid, 3–4 mm. diam., partially concealed by the perigyniums, each enclosed at first in a white false membrane which soon flakes away exposing a black, firmly agglutinated spore mass. Spores dark reddish brown, subopaque, spherical to oval, sometimes laterally compressed, 16–22.5 μ, mostly 18–21 μ diam., densely ornamented with coarse, blunt tubercles.
On Cyperaceae:
Carex siderosticha Hance.
Type locality and host: Dresden, Germany, on *Carex riparia* Curt.
Distribution: Shensi; also in Japan, Russia, Europe, North America.

MELANOPSICHIUM Beck

Ann. Nat. Hofmus. Wien 9: 122. 1894.

Sori in various parts of the host, causing the formation of conspicuous galls. Spores not aggregated into balls, developed in cavities in the host tissue, permanently imbedded in a mucilaginous matrix, discharging from the mass by absorption of water, of medium size.

Spores chiefly subhyaline, verrucose	*M. inouyei*
Spores chiefly brownish, echinulate	*M. pennsylvanicum*

Melanopsichium inouyei (P. Henn. & Shirai) comb. nov.
Uredo inouyei P. Henn. & Shirai apud P. Henn., in Engl. Bot. Jahrb. 28: 263. 1901.
Cintractia machili Hino & Nagaoka, Bull. Miyazaki Coll. Agr. For. 3: 55. 1931.
Ustilago machili S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 89. 1935.
Ustilago inouyei S. Ito & Yoshinaga apud S. Ito & Homma, Trans. Sapporo Nat. Hist. Soc. 15: 113. 1938.

Sori in the winter buds, forming conspicuous lobate galls, up to 3.5 cm. in length, protected by smooth, yellow to brown host tissue which ruptures irregularly disclosing deep brown, agglutinate spore masses. Spores formed in cavities, chiefly oval to ellipsoid, often subglobose, oblong, or somewhat irregular, 10.5–21 x 6.5–13 μ; epispore 1.5 μ thick, subhyaline to pale buff or pale olivaceous, densely verrucose, verrucae rather irregular.
On Lauraceae:
Machilus sp.
Type locality and host: Tosa, Japan, on ? *Symplocos* sp.
Distribution: Szechwan; also in Japan.

Melanopsichium pennsylvanicum Hirschh., Not. Mus. La Plata 6: 149. 1941.
Melanopsichium pennsylvanicum Hirschh. var. *besseyanum* Zundel, Mycologia 35: 183. 1943.
Melanopsichium pennsylvanicum Hirschh. var. *caulicola* Zundel, Mycologia 35: 184. 1943.

Sori in the inflorescences, stems and leaves, causing the formation of irregular, conspicuous, hard galls, variable in size, up to 3 cm. in length. Spores permanently and firmly agglutinate, globose, ovoid, oval or oblong, often somewhat irregular, 7–14 μ diam. or 7.5–16 x 6–12 μ, light to medium olivaceous brown, finely to distinctly echinulate, with more or less evident hyaline gelatinous envelopes.

On Polygonaceae:
Polygonum glabrum Willd.
Polygonum lapathifolium L.
Polygonum ? minus Hudson
Polygonum sp.
Type locality and host: Kansas, United States, on *Polygonum pennsylvanicum* L.
Distribution: Chekiang, Kiangsu, Kweichow, Szechwan, Taiwan, Yunnan; also in India, Indo-China, Japan, Russia, Australia, Europe, North America.

FARYSIA Racib.

Bull. Intern. L'Acad. Sci. Cracovie 354. 1909.

Sori in the ovaries or surrounding the peduncles, each covered at first by a false membrane which dehisces later. Spore mass traversed by numerous fascicles of hyphae, pulverulent at maturity. Spores not aggregated into balls, of small to medium size.

Mass of spores and fascicles brownish olive	*F. subolivacea*
Mass of spores and fascicles dark brown to nearly black	
Sori 2–4 mm. in diameter	*F. butleri*
Sori 3–12 mm. in diameter	*F. orientalis*

Farysia butleri (Syd.) Syd., Ann. Myc. 17: 42. 1919.

Ustilago butleri Syd., Ann. Myc. 4: 424. 1906.
Farysia caricis-filicinae S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 91. 1935.

Sori in the ovaries, subgloboid, 2–4 mm. diam., each enclosed in a brownish fungous membrane which soon ruptures disclosing a black dusty spore mass intermixed with brown olive hyphal fascicles. Fascicles usually not profuse, yellowish olive, 10.5–22.5 μ wide. Spores predominently globose to subglobose, often ovoid, oval, or irregular, occasionally with one or both ends tapering, 5.4–9.5 μ diam. or 6.7–10.5 x 6–8.7 μ, deep olivaceous brown, striate-verrucose, often more or less areolate, frequently each with an evident central globule.
On Cyperaceae:
Carex cruciata Wahl.
Type locality and host: Assam, India, on *Carex cruciata*.
Distribution: Fukien, Hainan, Kwangtung, Kwangsi, Kweichow, Sikang, Szechwan, Taiwan; also in India, Java.

Farysia orientalis Ling, Sydowia 3: 130. 1949.

Sori destroying the ovaries, 3–12 mm. diam., each covered with a thick, brownish fungous membrane of prosenchymatous tissue which later disintegrates revealing a "Chaetura Drab" to "Chaetura Black" (Ridgway) mass of spores and conspicuous hyphal fascicles. Fascicles very abundant and profuse, olivaceous, 7.5–20 μ wide, composed of a number of fine hyphae. Spores variable in shape and size, globose, oval ovoid, pyriform, or lenticular with elongate tapering ends, 4–6.7 μ diam. or 5–9.5 x 4–8 μ, most elongate ones up to 17 μ in length, frequently with an evident central globule, areolate in some cases; epispore olive brown, striate-verrucose.
On Cyperaceae:
Carex baccans Nees
Type locality and host: Ootacamund, India, on *Carex baccans*.
Distribution: Yunnan; also in Burma, Ceylon, India.

Farysia subolivacea (P. Henn.) Cif., Nuovo Giorn. Bot. Ital. 4: 258. 1933.

Ustilago subolivacea P. Henn., Ann. R. Inst. Bot. Roma 6: 84. 1896.

Sori in the ovaries, subgloboid, 3–7 mm. diam., at first more or less concealed by the perigyniums, soon exposing the "Brownish Olive" (Ridgway) masses of spores

and hyphal fascicles. Fascicles usually profusely developed, 7.5–30 μ wide. Spores globose to oval, or oblong, 4.5–7.5 μ diam. or 5–10 x 4.5–6 μ, elongate and irregular ones rarely up to 13.4 x 6 μ, light to medium olivaceous brown, frequently with evident central globules, verrucose, sometimes verrucae arranged in irregular striae.

On Cyperaceae:

Carex nemostachys Steud.

Carex simulans C. B. Clarke

Type locality and host: Somalia, Africa, on *Carex ramosa* Schkuhr.

Distribution: Szechwan; also in Africa.

The determination of this species is uncertain, as the type has not been available for study.

SOROSPORIUM Rud.

Linnaea 4: 116. 1829.

Sori in the inflorescences, forming pulverulent spore masses. Spore-balls consisting of numerous spores, semi-permanent or evanescent at maturity, invested at earlier stages by mycelial strands which become gelatinized later. Spores of small to medium size.

Sori involving the inflorescences	
Sori completely concealed at maturity	*S. cantonensis*
Sori more or less exposed at maturity	
Spores under 8 μ in length	
Spores smooth	*S. andropogonis-aciculati*
Spores punctate	*S. formosanum*
Spores exceeding 8 μ in length	
Outer spores indistinctly pitted	*S. paspali-thunbergii*
Outer spores verruculose to verrucose	
Sori under 2 cm. in length	*S. cymbopogonis-distantis*
Sori exceeding 2 cm. in length	
Spores surrounding a central columella	*S. flagellatum*
Spores intermixed with numerous filaments	*S. caledonicum*
Sori in the ovaries	
Spores verruculose	*S. cymbopogonis-distantis*
Spores coarsely verrucose or tuberculate	
Sori 2–3 mm. wide	*S. anthistiriae*
Sori 5–7 mm. wide	*S. ehrenbergii*

Sorosporium andropogonis-aciculati (Petch) Petch, Ann. Roy. Bot. Gard. Peradeniya 5: 227. 1912.

Ustilago andropogonis-aciculati Petch, Ann. Roy. Bot. Gard. Peradeniya 4: 303. 1909.

Sori destroying entire inflorescences, concealed first by the leaf sheaths, then protruding, linear, 2–6 cm. long, 1–2 mm. wide, each enclosed by a pallid false membrane which lacerates from the apex revealing a granular black spore mass surrounding a number of long, slender filaments of host tissue. Spore-balls rather permanent, subglobose to oblong, many spored, opaque, 30–70 x 20–67 μ. Spores chiefly globose to oval, 4.2–6.2 μ diam.; epispore smooth, thin, light olivaceous brown, outer and inner spores uniformly colored.

On Gramineae:

Rhaphis aciculata (Retz.) Desv. (= *Andropogon aciculatus* Retz.)

Type locality and host: Peradeniya, Ceylon, on *Andropogon aciculatus*.

Distribution: Taiwan; also in Ceylon, Philippine Islands.

Sorosporium anthistiriae (Cobb) Ling, Myc. Papers Imp. Myc. Inst. 11: 9. 1945.

Tolyposporium anthistiriae Cobb, Agr. Gaz. N.S.W. 3: 1006. 1892.

Sorosporium holstii P. Henn., in Engler, Pflanzenw. Ost.-Afrikas Nachb. C: 49. 1895.

Tolyposporium anthistiriae P. Henn., Hedw. 37: 283. 1898.

Sori in the ovaries, infecting occasional or all spikelets in the inflorescence, protruding conspicuously beyond the glumes, cylindrical, tapering at both ends, 1.5–4.5 cm. long, 2–3 mm. wide, each enclosed by a whitish or yellowish false membrane which breaks up irregularly or lacerates into long shreds, exposing a granular, black spore mass intermixed with 5–8 threads of host tissue. Spore-balls subglobose to oblong, opaque, permanent, 45–175 x 37–115 μ. Spores globose, ovoid or ellipsoidal, mostly somewhat angular; outer spores 9.5–16.5 x 8.5–14 μ, epispore coarsely granulate-verrucose, dark reddish brown, 1.2–2 μ thick, often unevenly thickened; inner spores almost hyaline to light brown, smooth, smaller in size.

On Gramineae:

Heteropogon contortus (L.) Roem. & Schultes

Themeda gigantea (Cav.) Hack.

Themeda triandra Forsk.

Type locality and host: New South Wales, Australia, on *Themeda ciliata* (L. f.) Hack.

Distribution: Fukien, Honan, Hopeh, Hunan, Hupeh, Kiangsu, Szechwan, Chekiang; also in Australia, Africa.

Sorosporium caledonicum Pat., Bull. Soc. Myc. Fr. 3: 173. 1887.

Sorosporium contortum Griff., Bull. Torrey Bot. Club 31: 83. 1904.

Sori destroying the racemes, linear, 3–7 cm. long, partially concealed by the leaves, each enclosed by a light brown false membrane which later lacerates from the apex into long shreds disclosing a black granular spore mass intermixed with a number of long slender filaments of host tissue; cells of the false membrane subhyaline, thick-walled, cubical to oblong. Spore-balls permanent, opaque, subglobose to oblong, 38–106 μ long. Spores globose to oval, rarely polyhedral, 8.5–11.5 μ diam. or 10–13 x 8.5–10 μ, epispore 1–1.5 μ thick; outer spores deep reddish brown, verruculose on the free surface; inner spores subhyaline to light yellow brown, smooth.

On Gramineae:

Heteropogon contortus (L.) Beauv.

Type locality and host: New Caledonia, on *Heteropogon contortus*.

Distribution: Szechwan; also in India, New Caledonia, North America.

Sorosporium cantonensis Zundel, Mycologia 31: 584. 1939.

Sori in individual inflorescences, completely and tightly enclosed by the reduced leaves, 5–8 mm. long, less than 1 mm. wide, each covered by a light grayish false membrane composed of hyaline, oblong sterile cells. Spore mass compact, black, surrounding a central, simple columella. Spore-balls usually opaque, oval to oblong, semi-permanent, 52–180 x 37–107 μ. Spores mostly polyhedral, often subglobose, ovoid or ellipsoid, 13.5–18.5 x 12–15 μ, the most elongate up to 21 μ long, epispore 1.5–2 μ thick; outer spores deep reddish brown, verrucose; inner spores light brown, smooth or indistinctly verruculate.

On Gramineae:

Cymbopogon tortilis (Presl) Hitchc. (= *C. hamatulus* A. Camus)

Type locality and host: Canton, Kwangtung, on *Cymbopogon hamatulus*.

Distribution: Known only from the type locality.

Sorosporium cymbopogonis-distantis sp. nov. (Fig. 3,C; and 4,B)

Soris in ovariis evolutis, glumis ex parte tectis, 0.5–1 cm. longis, 1–2 mm. latis, vel inflorescentiam destruentibus, spatha tectis, 1–1.7 cm. longis, linearibus, utrinque attenuatis, primum singulis membrana falsa brunnea tectis, hac membrana dehiscenti et massam subagglutinatam sporarum et fila tenuia hospitis detegenti. Glomerulis sporarum opacis, ovalibus vel ellipsoideis, 65–100 x 50–90 μ, in maturitate evanescentibus; sporis peripheriis plerumque polyedricis, saepe subglobosis ovalibusve, 13.5–16.5 μ, rare usque 19 μ longis, 10.5–13.5 μ latis, granulosis, episporis atro-rubro-brunneis, dense verrucosis; sporis centralibus in forma et dimensionibus similibus, sed pallidioribus et minus distincte verruculosis.

Sori in the ovaries, partially concealed by the glumes, 0.5–1 cm. long, 1–2 mm. wide, or destroying individual inflorescences, concealed by the spathes, 1–1.7 cm. long, linear, tapering at both ends, each covered at first by a wood brown false membrane which dehisces exposing a semi-agglutinate spore mass surrounding several slender threads of host tissue. Spore-balls opaque, oval to ellipsoid, 65–110 x 50–90 μ, evanescent at maturity; peripherical spores mostly polyhedral, often subglobose to oval, 13.5–16.5 μ, rarely up to 19 μ long, 10.5–13.5 μ wide, contents granular, epispore deep reddish brown, densely verrucose; inner spores similar in shape and size, light olivaceous, with less distinct verruculations.

On Gramineae:

Cymbopogon distans (Nees) W. Wats.

Type locality and host: Vicinity of Chengtu, Szechwan, on *Cymbopogon distans* (Nov. 1947, K. R. Lin).

Distribution: Known only from the type locality.

Sorosporium ehrenbergii Kuehn, Mitt. Ver. Erdkunde 87. 1887.

Tolyposporium ehrenbergii Pat., Bull. Soc. Myc. Fr. 19: 254. 1903.

Tolyposporium filiferum Busse, Arb. Biol. Abt. Land-Forstwirtsch. 4: 384. 1904.

Sorosporium filiferum Zundel, Mycologia 22: 148. 1930.

Sori in the ovaries, oblong, somewhat tapering at both ends, often curved, 1.5–2 cm. long and 5–7 mm. wide, each enclosed in a pale yellow, rather persistent false membrane which later ruptures from the apex disclosing a granular, black spore mass surrounding a number of shreds of host tissue; sterile cells of the false membrane hyaline, globose to oval, mostly much larger than the spores. Spore-balls rather permanent but easily broken, subglobose to oblong, or irregular, 38–123 x 34–93 μ. Spores from the periphery of spore-balls medium to deep reddish brown, opaque and coarsely tuberculate on the free surface, globose to oval, or somewhat angular, 10.5–15 μ long; inner spores subhyaline to pale brownish, smooth, globose to ellipsoid, 9–15 μ long; epispore 1.5–2 μ thick.

On Gramineae:

Sorghum vulgare Pers.

Type locality and host: Egypt, on *Sorghum vulgare*.

Distribution: Hopeh; also in India, Russia, Africa.

Sorosporium flagellatum Syd. & Butl., Ann. Myc. 5: 489. 1907.

Ustilago burmanica Syd. & Butl., Ann. Myc. 10: 250. 1912.

Sorosporium geminellum Syd. & Butl., Ann. Myc. 10: 253. 1912.

Sori in the inflorescences, cylindrical, 2–6 cm. long, concealed at first by the leaf sheaths, later protruding, each enclosed by a brown false membrane which ruptures irregularly revealing the dark spore mass surrounding a simple columella. Spore-balls subglobose to oblong, evanescent, 37–77.5 x 30–52.5 μ, rarely up to 120 μ long. Spores globose to oval, occasionally elongate or angular, 11–16.5 μ diam. or 12–17 x 10.5–15 μ; epispore reddish brown, 1–1.3 μ thick, verruculose.

On Gramineae:
Ischaemum timorense Kunth var. *peguense* Hack.
Type locality and host: Malabar, India, on *Ischaemum timorense*.
Distribution: Fukien, Taiwan; also in Burma, India, Java.

Sorosporium formosanum (Saw.) Saw., Dept. Agr. Gov't. Res. Inst. Formosa Rep. 35: 29. 1928.

Ustilago digitariae (Ktze.) Rab. f. *panici-repentis* Kuehn, Hedwigia 15: 5. 1876.
Ustilago formosana Saw., Trans. Taiwan Nat. Hist. Soc. 8: 16. 1918.
Ustilago overeeimi Cif., Nuovo Giorn. Bot. Ital. n. s. 40: 254. 1933.
Ustilago amadelpha Syd. & Butl. var. *glabriuscula* Cif., Nuovo Giorn. Bot. Ital. 40: 255. 1933.
Sorosporium punctatum Malenç. & Yen, Rev. Myc. 2: 130. 1937.
Sorosporium yoshinagae Zundel, Mycologia 31: 589. 1939.
Sorosporium overeeimi Malenç., Rev. Myc. 10: 121. 1945.

Sori destroying the inflorescences, 4–10 cm. long, each covered at first by a pale brown false membrane which gradually flakes away revealing numerous long, slender threads of host tissue intermixed with the dark spore mass. Spore-balls rather permanent, 60–195 x 45–115 μ, reniform or oblong. Spores globose to oval, 5–7.5 x 4.5–6.5 μ, finely punctate, olivaceous brown; inner spore lighter in color.
On Gramineae:
Panicum repens L.
Type locality and host: Taiwan, on *Panicum repens*.
Distribution: Fukien, Taiwan; also in Ceylon, India, Japan, Java, Europe, Africa.

Sorosporium paspali-thunbergii (P. Henn.) S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 94. 1935.

Ustilago paspali-thunbergii P. Henn., Hedwigia 43: 140. 1904.
Sorosporium paspali McAlp., Smuts Austral. 180. 1910.

Sori in the inflorescences, cylindrical, up to 10 cm. long, in earlier stages concealed by the leaf sheaths but protruding later, each enclosed in a pale brown false membrane which ruptures irregularly revealing the semi-agglutinate but finally powdery spore mass and a simple, frequently twisted columella. Spore-balls evanescent, subglobose to oblong, often irregular, 28–70 x 26–56 μ, surrounded by several layers of mycelial strands which become gelatinized at maturity. Spores mostly angular, often subglobose, oval or oblong 12–19 x 9.5–14.5 μ, epispore 1.3–2 μ thick, usually unevenly thickened; outer spores deep reddish brown, finely and indistinctly pitted; inner spores clear reddish brown, smooth or nearly smooth.
On Gramineae:
Paspalum scrobiculatum L.
Paspalum sp.
Type locality and host: Nikko, Japan, on *Paspalum thunbergii* Kunth.
Distribution: Fukien, Hopeh, Kiangsi, Kwangtung, Taiwan; also in Ceylon, Hawaii, India, Japan, Philippine Islands, Australia.

TOLYPOSPORIUM Woronin

Abh. Senck. Nat. Ges. 12: 577. 1882.

Sori usually in the ovaries, forming granular spore masses at maturity. Spore-balls composed of numerous, permanently united spores. Spores bound together by ridged folds or thickenings of their outer walls, of small to medium size.

Sori infecting only occasional ovaries in the inflorescence	
Sori subglobose, 1.5–3 mm. in length	*T. evernium*
Sori oval or ovoid, 3–4 mm. in length	*T. bullatum*
Sori infecting almost all of the ovaries	*T. globuligerum*

Tolyposporium bullatum (Schroet.) Schroet., Krypt. Fl. Schles. 3: 276. 1887.

Sorosporium bullatum Schroet., Abh. Schles. Ges. Abth. Nat. Med. 1869–72: 6. 1871.

Sori in ovaries, infecting only a few spikelets in a panicle, oval or ovoid, 3–4 mm. in length, each covered by a green, smooth membrane which ruptures later disclosing a granular black spore mass. Spore-balls opaque, globose to oblong, 78–375 x 68–225 μ. Spores globose to oval, 7.5–12 x 6–9 μ, pale olivaceous yellow, folded in ridges by which the spores are bound together and which on rupture of spore-balls show as truncate projections at spore margins, epispore 1.5 μ thick.

On Gramineae:

Echinochloa crus-galli (L.) Beauv.

Echinochloa crus-galli (L.) Beauv. var. *mitis* (Pursh) Peterm.

Type locality and host: Silesia, on *Panicum crus-galli* L.

Distribution: Fukien, Szechwan, Taiwan; also in Japan, Russia, Europe, North America.

Tolyposporium evernium Syd., Ann. Myc. 37: 443. 1939. (Fig. 4,C)

Sori in the ovaries, infecting only occasional ones, subglobose, 1.5–3 mm. diam., each enclosed by a thick smooth membrane of host tissue. Spore-balls opaque, irregular in shape, subglobose or pyriform, often broadly ellipsoidal, 70–336 x 64–242 μ, permanent. Spores globose to oval, covered by 5–10 short projections by which the spores are firmly bound together, 5.6–12.6 x 5.6–10.5 μ, averaging 9.1 x 8.2 μ; outer spores light reddish brown to reddish brown, epispore 0.5 μ thick; inner spores almost hyaline.

On Gramineae:

Paspalum distichum L.

Type locality and host: Panjab, India, on *Paspalum distichum*.

Distribution: Kiangsu; also in India.

Tolyposporium globuligerum (Berk. & Br.) Ricker, Jour. Myc. 11: 112. 1905.

Thecaphora globuligera Berk. & Br., Trans. Linn. Soc. II. 1: 407. 1879.

Sori infecting most of the ovaries in the inflorescence, oblong or cornute, 3–5 mm. long, partially hidden by the glumes, each covered by a thick, green, smooth membrane of host tissue which finally ruptures disclosing a granular black spore mass. Spore-balls opaque, subglobose to ellipsoidal, sometimes oblong or irregular, permanent, 70–220 x 45–150 μ. Spores globose to ellipsoid, often angular, 6.7–10.5 x 6–9 μ, light olivaceous yellow, each with 4–7 truncate projections by which the spores are firmly bound together, epispore 1.5 μ thick.

On Gramineae:

Leersia japonica Makino

Type locality and host: Brisbane, Australia, on *Leersia hexandra* Swartz.

Distribution: Szechwan; also in India, Africa, Australia, North and South America.

DERMATOSORUS Saw.

Mycologia 41: 267. 1949.

Sori in the ovaries, pulverulent, each enclosed in a false membrane which dehisces eventually. Spore-ball consisting of numerous spores invested by a cortex of pseudoparenchymatous tissue. Spores loosely united, of small to medium size.

Dermatosorus eleocharidis Saw. apud Ling, Mycologia 41: 268. 1949.

Sori in the ovaries, often involving the basal parts of anthers, with glumes intact, each covered at first by a firm, thick, black false membrane which is composed of

yellow brown cells, firmly bound together, ovoid, ellipsoidal or angular in outline, 9–16 x 6.5–15 μ diam., with walls 1.5 μ thick, and which later ruptures irregularly revealing an aggregate of spore-balls. Spore-balls many-spored, rectangular, ellipsoidal or subglobose, opaque, 112–606 x 88–358 μ diam., each covered by a delicate but rather permanent cortex of pseudoparenchymatous tissue, 15–75 μ thick, consisting of reddish brown cells, 3–6.5 μ diam., with walls 1 μ thick. Spores loosely united, globose to ellipsoidal, 6–11 μ diam., chiefly 7–9 μ; epispore smooth, reddish brown, approximately 1 μ thick.

On Cyperaceae:

Eleocharis dulcis Trin.

Type locality and host: Kaohsiung, Taiwan, on *Eleocharis dulcis*.

Distribution: Known only from the type locality.

EXCLUDED SPECIES

Cintractia leucoderma Ling, Mycologia 41: 264. 1949. = Cintractia scleriae.

Entyloma bidentis Saw., Taiwan Agr. Res. Inst. Rep. 85: 43. 1943. = Entyloma guaraniticum.

Farysia olivacea Saw., Trans. Taiwan Nat. Hist. Soc. 32: 29. 1942. = Farysia butleri.

Farysia pseudocyperi Zundel, Mycologia 23: 297. 1931. = Farysia butleri.

Melanopsichium austro-americanum in several reports = Melanopsichium pennsylvanicum.

Sorosporium arundinellae Syd. = Ustilaginoidea arundinellae P. Henn.

Sorosporium clintonii Ling, Myc. Papers Imp. Myc. Inst. 11: 10. 1945. = Sorosporium anthistiriae.

Sphacelotheca seymouriana Teng, Contr. Biol. Lab. Sci. Soc. China 8: 148. 1932. = Sphacelotheca taiana.

Sphacelotheca themedae Ling, Myc. Papers Imp. Myc. Inst. 11: 9. 1945. = Sphacelotheca anthistiriae var. punctata.

Tilletia barclayana Yen, Contr. Inst. Bot. Nat. Acad. Peiping 3: 55. 1935. = Tilletia pennisetina.

Ustilago egenula Zundel, Mycologia 35: 167. 1943. = Ustilago spermophora.

Ustilago flavo-nigrescens Keissler, in Handel-Mazzetti's Symbolae Sinicae 2: 4. 1937. = Farysia butleri.

Ustilago grandis Wei & Hwang, Nanking Jour. 9: 34. 1941. = Hyphomycetes.

Ustilago koordersiana Yates, Philipp. Jour. Sci. C. 12: 315. 1917. = Ustilago cordai.

Ustilago panici-frumentacei Ling, Myc. Papers Imp. Myc. Inst. 11: 6. 1945. = Ustilago sphaerogena.

Ustilago penniseti Sacc., Philipp. Jour. Sci. C. 18: 596. 1921. = Sphacelotheca penniseti-japonica.

Ustilago pustulata Teng, Contr. Biol. Lab. Sci. Soc. China 8: 148. 1932. = Sphacelotheca penniseti-japonica.

Ustilago tonkinensis Reinking, Philipp. Agr. 8: 120. 1919. = Sphacelotheca tanglinensis.

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  Tilletia pennisetina
Pennisetum compressum = P. alopecuroides
Pennisetum japonicum = P. alopecuroides
Phyllostachys congesta
  Ustilago shiraiana
Phyllostachys makino
  Ustilago shiraiana
Phyllostachys spp.
  Ustilago shiraiana
Physalis angulata
  Entyloma australe
Physalis ? minima
  Entyloma australe
Polygonum barbatum
  Ustilago cordai
Polygonum barbatum var. gracile
  Ustilago cordai
Polygonum bistorta
  Sphacelotheca hydropiperis var. borealis
Polygonum bungeanum
  Ustilago cordai
Polygonum caespitosum
  Sphacelotheca hydropiperis
  Ustilago cordai
Polygonum caespitosum var. longisetum
  Sphacelotheca hydropiperis
  Ustilago cordai
Polygonum campanulatum var. fulvidum
  Ustilago ocrearum
Polygonum chinense
  Ustilago emodensis
Polygonum glabrum
  Melanopsichium pennsylvanicum
Polygonum hydropiper
  Sphacelotheca hydropiperis
  Ustilago cordai
Polygonum hydropiper var. flaccidum
  Ustilago cordai
Polygonum japonicum
  Ustilago filamenticola
Polygonum lapathifolium
  Melanopsichium pennsylvanicum
  Ustilago reticulata
Polygonum lapathifolium var. lanatum
  Ustilago reticulata
Polygonum ? minus
  Melanopsichium pennsylvanicum
Polygonum morrisonense = P. runcinatum
Polygonum nepalensis
  Ustilago nepalensis
Polygonum nummularifolium
  Sphacelotheca hydropiperis
Polygonum opacum
  Ustilago reticulata
Polygonum pilosum
  Ustilago koenigiae
Polygonum runcinatum
  Ustilago tuberculiformis
Polygonum sagittatum
  Sphacelotheca hydropiperis

Polygonum sagittifolium
  Sphacelotheca hydropiperis
Polygonum senticosum
  Sphacelotheca hydropiperis
Polygonum spp.
  Melanopsichium pennsylvanicum
  Ustilago anhweiana
  Ustilago emodensis
  Ustilago ocrearum
Polygonum strindbergii
  Sphacelotheca hydropiperis
Polygonum viscosum
  Ustilago reticulata
Pulsatilla chinensis
  Urocystis anemones
Rhaphis aciculata
  Sorosporium andropogonis-aciculati
Rheum franzenbachii
  Tilletia rhei
Rhynchospora corymbosa
  Cintractia scleriae
Rottboellia compressa = Manisuris compressa
Rumex aquaticus
  Ustilago warmingii
Ununculus vernyii
  Entyloma microsporum
Saccharum arundinaceum
  Sphacelotheca sacchari
Saccharum officinarum
  Ustilago scitaminea
Saccharum sinense
  Ustilago scitaminea
Saccharum sp.
  Sphacelotheca sacchari
Sagittaria sagittifolia
  Doassansiopsis horiana
Sagittaria trifolia
  Doassansia opaca
Scilla chinensis = S. sinensis
Scilla sinensis
  Ustilago vaillantii
Senecio formosana
  Entyloma compositarum
Setaria italica
  Ustilago crameri
Setaria lutescens
  Tilletia setariae
  Ustilago neglecta
Setaria viridis
  Ustilago neglecta
Silene tatarinowii
  Ustilago violacea
Silene tenuis var. rubescens
  Ustilago violacea
Sorghum vulgare
  Sorosporium ehrenbergii
  Sphacelotheca cruenta
  Sphacelotheca reiliana
  Sphacelotheca sorghi
  Ustilago kenjiana
Sorghum nitidum
  Sphacelotheca taiana
Sporobolus indicus
  Ustilago sporoboli-indici
Themeda gigantea
  Sorosporium anthistiriae
Themeda triandra
  Sorosporium anthistiriae
  Sphacelotheca anthistiriae
  Sphacelotheca anthistiriae var. punctata
Triticum aestivum
  Tilletia caries
  Tilletia foetida
  Urocystis agropyri
  Ustilago nuda
Zea mays
  Sphacelotheca reiliana
  Ustilago maydis
Zizania latifolia
  Ustilago esculenta

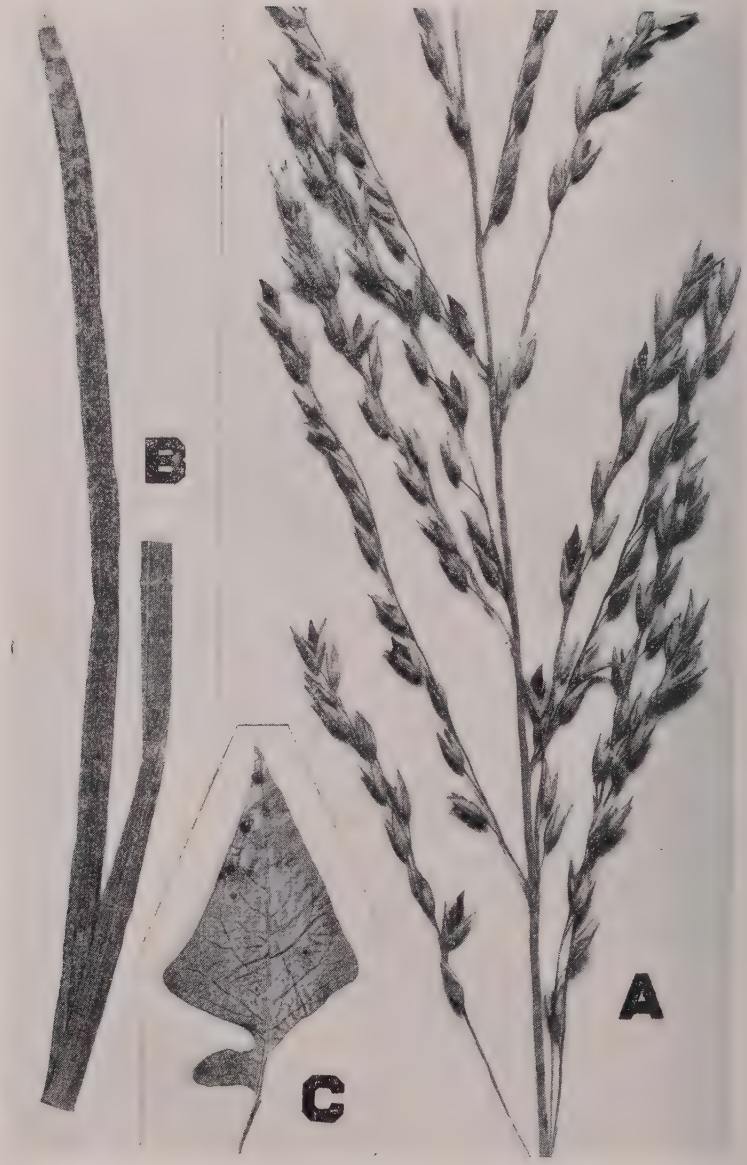

Fig. 1. A. *Tilletia arundinellae* on *Arundinella anomala*, type. × 2. **B.** *Entyloma eleocharidis* on *Eleocharis dulcis*, type. × 1. **C.** *Ustilago tuberculiformis* on *Polygonum runcinatum*, Taiwan collection. × 1.

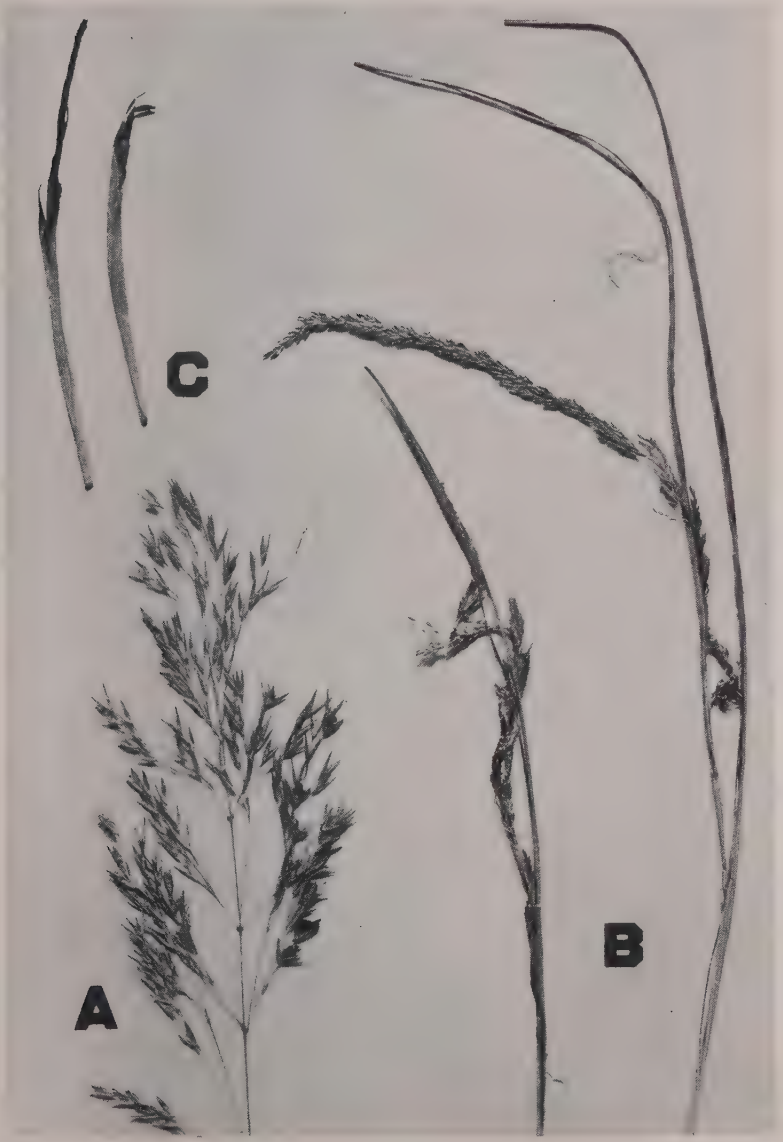

Fig. 2. A. *Tilletia deyeuxiae* on *Deyeuxia sylvatica* var. *laxiflora*, type. **B.** *Ustilago sporoboli-indici* on *Sporobolus indicus*, type. **C.** *Sphacelotheca ophiuri* on *Ophiurus monostachys*, Yunnan collection. All × 1.

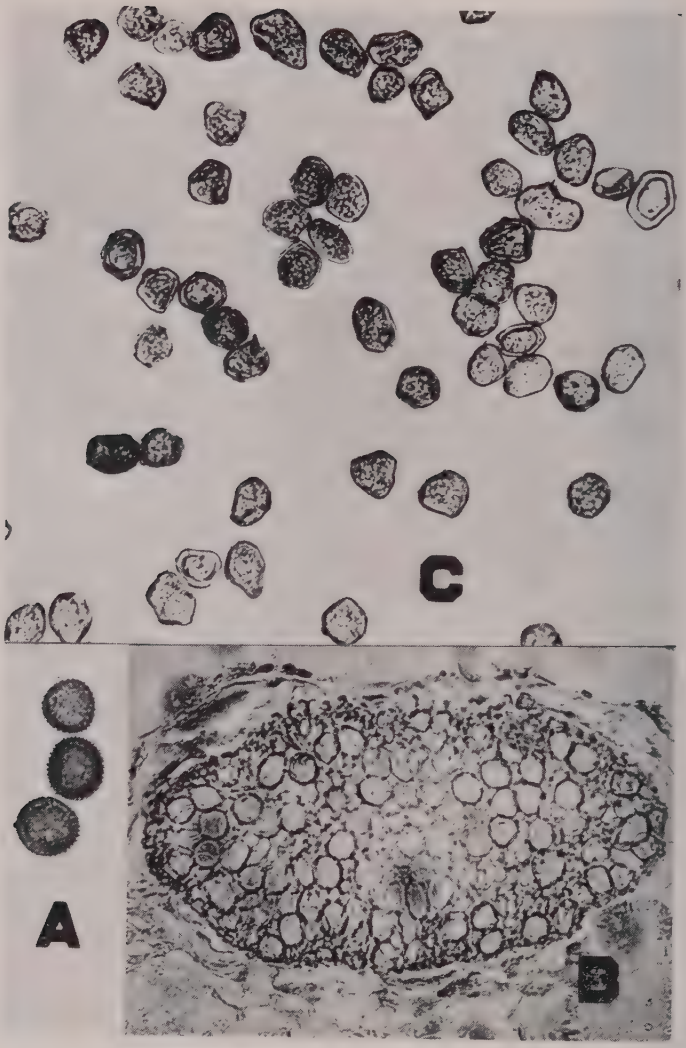

Fig. 3. **A.** *Tilletia rhei*, teleutospores, type. × 500. **B.** *Burrillia ajrekari*, sorus, Taiwan collection. × 450. **C.** *Sorosporium cymbopogonis-distantis*, teleutospores, type. × 500.

Fig. 4. A. *Sphacelotheca apludae* on *Apluda mutica* var. *aristata*, type. **B.** *Sorosporium cymbopogonis-distantis* on *Cymbopogon distans*, type. Left, healthy plant; center, plant with infection involving the inflorescences; right, plant with infection in the ovaries. **C.** *Tolyposporium evernium* on *Paspalum distichum*, Kiangsu collection. All × 1.

4(3):353–398 FARLOWIA November, 1953

THE AQUATIC HYPHOMYCETES OF CALIFORNIA [1]

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The term "aquatic fungi" has been customarily applied to the aquatic Phycomycetes. It has, however, become apparent in recent years that the Phycomycetes, though still the dominant group from the standpoint of numbers, are only a part of a very diversified fresh-water flora. A number of discomycetous genera, *Vibrissea* Fr., *Apostemidium* Karst. and *Mitrula* Fr. in particular, encompass species that are wholly aquatic. These organisms grow on twigs submerged in cold fresh-water streams and lakes and discharge their spores beneath the surface of the water. In the Pyrenomycetes at least one member of the *Metasphaeria-Melomastia* alliance, as well as the striking *Loramyces juncicola* Wes. (Weston, 1929), are known to be fresh-water aquatics. Thus with the Phycomycetes and Ascomycetes represented in the fresh-water flora, it is not surprising that some of the ubiquitous Fungi Imperfecti have adapted themselves to the aquatic habit.

De Wildeman in 1893, 1894 and again in 1895 observed the spores of several species of fungi in his collections of algae. Three of these species, *Tetracladium marchalianum*, *Fusarium elongatum* (now *Anguillospora longissima*) and *Lemonniera aquatica*, were placed in the Moniliales. The other species, *Clavariopsis aquatica*, was placed in the Mycelia Sterilia because he was unable to observe the germination of the tetraradiate spores.

Though De Wildeman was the first to recognize these free-floating objects as spores of fungi, Riensch (1888) was the first to describe them. Reinsch thought the spores of *Tetracladium marchalianum* were free-floating algae and described them as varieties of his alga *Cerasterias raphidioides*. For many years, from 1895 to 1935, the fungus and the alga were involved in a bewildering synonomy that has only recently been settled (Karling, 1935).

To the aquatic Fungi Imperfecti, Kegel (1906) added a monotypic genus, *Varicosporium Elodeae*, that he found growing on some *Elodea* that had been used in an experimental study. In 1912, Grove added still another species to the group, *Tridentaria setigerum* (now *Tetracladium setigerum* (Grove) Ing.). From 1912 to 1942 matters lay in abeyance save for a few sporadic accounts of some of these six species which placed two of them within the continental limits of North America.

C. T. Ingold, while engaged in an investigation of another kind, observed a large number of fungus spores floating in the waters of a stream near

[1] This paper presents a portion of a doctorate thesis completed at the University of California, Berkeley.

Leicester. He found that these spores came from fungi growing on decaying leaves in the stream. He then embarked on a long series of investigations (1942, 1943a, 1943b, 1944, 1949) of the fungus flora of these decaying leaves. He studied the development and the morphology of the spores in a most careful and meticulous way. Ingold's outstanding contributions, added to those of the earlier investigators, brought the total of fresh-water Fungi Imperfecti to sixteen genera and twenty-six species.

Virtually nothing was known about these organisms in North America except for an isolated account or two of *Tetracladium marchalianum* (Karling, 1935) and *Varicosporium Elodeae* (Bessey, 1939). It seemed of value, therefore, to discover the nature and distribution of the aquatic Fungi Imperfecti of California.

A survey was made of the fresh-water streams, lakes and ponds, both permanent and temporary, throughout the greater part of the state of California. Nearly all of the waters explored contained representatives of this group; the exceptions will be discussed later. Fifteen genera and twenty-two species were collected (Fig. 1); five of these species appear to be undescribed. The substratum proved to be quite variable but the fungi were found most commonly on leaves that had undergone considerable decay. Though a vascular system seemed to be necessary as a substratum, all gymnosperm material examined was void of these fungi.

1. *Collection and isolation.* The leaves, or other debris, best suited for collection were those in which decay had proceeded to the point where only the vascular system remained; leaves belonging to such genera as *Salix*, *Populus*, *Alnus*, *Acer*, *Platanus*, *Cornus*, *Fraxinus* and *Rubus* skeletonize well and are specially suitable for these aquatics. Even on leaves that do not skeletonize well, such as various species of *Quercus*, a number of aquatic Hyphomycetes was found. Although they occur in great abundance on leaf material, the aquatic Hyphomycetes are by no means entirely restricted to it. Maple samaras, peach stones, fern rhizomes, small twigs and decomposing sporophylls of *Isoetes*, onion scales and paper seemed to serve as well as leaves as substrata.

The collected material was brought into the laboratory and placed in crystallizing dishes partially filled with autoclaved tap or distilled water. In most instances, twelve to twenty-four hours later, large numbers of sporophores and spores were produced. Usually several species were represented on any one substratum. The spores, when shed, gradually settled to the bottom of the crystallizing dish. Using a Spencer Stereoscopic Dissecting Microscope with 15 X oculars and 3 X objectives, it was possible to pick up single spores with pasteur pipettes and transfer them to prune agar plates. Difco Prune Agar was used because it is a very clear medium and as such is ideal for microscopic examination of the planted spores through the bottom of the petri dish. At the end of twenty-four hours the plates were examined for germinated spores. Usually 100 percent germination had occurred and single germlings were cut out and transferred to a solid medium composed of 2 percent agar and 1 percent malt extract.

2. *Pure culture.* In those instances where the fungus grew more rapidly than the bacteria usually isolated with the spore, the bacterium-free hyphal tips were cut out and used to start pure cultures. If this was not the case, Raper's van Teighem ring technique (Raper, 1937) was employed. One rim of a van Teighem ring was notched to a depth of one or two millimeters in several places. The ring was placed in a petri dish with the notched rim on the bottom. The plates, after sterilization, were filled with malt agar to a level just above that of the notches. After the agar had solidified and all moisture on the glass surfaces had disappeared, the area confined by the ring was inoculated. The mycelium grew into the agar, through the notches and back to the agar surface again. Blocks of agar and mycelium cut from the growing edge of the colony were free of bacteria and were used to start pure cultures. Stock cultures were maintained on malt agar slants in test tubes two centimeters in diameter.

3. *Taxonomic criteria and definition of terms.* It is not the purpose of this work to delve into a profound and searching examination of the merits and demerits of the several systems of classification of the Fungi Imperfecti. Neither is it the purpose to erect a system of classification for the entire group of imperfects on the strength of an examination of a small number of specialized aquatics. It is necessary, however, to employ meaningful characters for the establishment of taxonomic criteria.

In the absence or relative rarity of the occurrence of sexual reproduction in the majority of Fungi Imperfecti, it is necessary to use the characters of the asexual reproductive structures. Thus it is the development and morphology of the asexual reproductive unit, the spore, that provides the basis for the taxonomic criteria. The greater part of these criteria were originally proposed by Vuillemin (1910, 1911) in which he discarded the saccardian system with its loosely used term "conidium" to a large extent. Vuillemin made a clear-cut distinction between conidiospores and thallospores and used this distinction as a point of departure.

According to Vuillemin (1910), the name "conidia" should be reserved for spores that are distinct from the mycelium from the beginning, i.e., they are not modifications of already existing hyphae. Conidia are also deciduous, i.e., they are set free from the conidiophore or the hypha that bears them as soon as they are mature. Thallospores, on the other hand, are at first a part of the vegetative system and are secondarily adapted to disseminative functions, i.e., merely enlarged or otherwise modified portions of already existing hyphae. Thallospores are also not deciduous and remain attached to the mycelium until decay of the latter sets them free. The thallospores were divided into three types, blastospores, hemispores and chlamydospores. In 1911, Vuillemin added a fourth type, the aleuriospore. The aleuriospore seemed to be an intermediate between the chlamydospore and the conidium and differed only in not being clearly set off from the hyphae from the beginning nor deciduous; in all other characters the aleuriospores were indistinguishable from conidia.

In the aquatic Hyphomycetes *all* of the fungi examined released their

spores, as nearly as observation and germination studies could determine, as soon as the spores were mature. Thus it would appear that the aleuriospore is not a spore type to be found in this group if it were not for the fact that the remainder of Vuillemin's definitions and the amplifications made by Mason and Ingold of these definitions can be applied to many, if not all, of these fungi. The concept of the conidium and the aleuriospore was extended (Mason, 1933, 1937; Ingold, 1942) to include the insertion on and the manner of separation from the parent hypha. The conidium is inserted on the hypha by a surface less than the diameter of the hypha and the separating septum is formed just prior to the release of the conidium. The aleuriospore, on the other hand, is inserted on a surface equal in diameter to the hypha and is separated from the parent hypha by a septum that forms very early in the development of the spore. If these amendments of Mason and Ingold are accepted, the problem of differentiating between the aleuriospore and the conidium is not only greatly simplified, but a set of terms with ontogenetic implications is substituted for those less precise terms now in general use.

Great emphasis was placed by Vuillemin (1910) on the mode of attachment of the conidium. The conidium can be produced directly on the mycelium, or it may be borne on a differentiated conidiophore, or it may develop on or in a phialide. The phialide, as originally conceived and as regarded by Mason, Ingold and Langeron (1945), is conventionally described as a unicellular flask-shaped structure with a comparatively enlarged venter and a narrow, more or less attenuated, neck-like portion and bears conidia or a conidium (phialospore) at or within the tip. The sterigma of the Aspergillaceae provides a classical example of a phialide.

The terms that will be used in the body of the text are defined as follows:

Spore: A general term for the asexual reproductive bodies of the cryptogams.

Sporophore: The hypha that gives rise to the spore.

Conidium: A spore produced terminally on a hypha; the point of insertion is less than the diameter of the hypha that bears it and the septum which separates it from the hypha is formed just prior to its release.

Conidiophore: A differentiated hypha that bears conidia directly or phialides. When phialides are produced the conidiophore may be reduced to the phialide itself.

Phialide: A unicellular ampulliform structure which consists of an enlarged venter and a narrow neck-like portion and produces conidia at or within the tip.

Phialospore: A conidium borne on or in a phialide.

Aleuriospore: A modified terminal portion of a hypha that resembles and behaves like a conidium but is separated from the rest of the hypha by a septum formed very early in its development; the point of insertion is equal to the diameter of the hypha.

Aleuriophore: The hypha, relatively unmodified, that gives rise to the aleuriospores.

The initial separation into genera is based on the spore type, i.e., aleuriospores, conidia, chlamydospores. If, for example, Fungus A produces aleuriospores, Fungus B produces conidia and Fungus C produces its conidia on phialides, it follows that these three species must be placed in three separate genera regardless of the morphological similarity the spores may have to each other. In fact, if Vuillemin's system were to be followed more exactly, these three fungi would have to be placed in different orders.

A second criterion used to categorize genera is based on the manner of spore development. If both Fungus A and Fungus B produce spores with three lateral branches and in A the branches are produced simultaneously whilst in B the branches are produced successively, then these two fungi are assigned to different genera. As a third criterion, it follows that fungi having spores with branches should not be assigned to a genus characterized by fungi with spores unbranched. The nature and number of branches is also taken into consideration.

Using the criteria set forth above, it is possible to arrange the aquatic Fungi Imperfecti into seemingly natural groups.

THE GENERA

All of the Moniliaceous aquatic Fungi Imperfecti have a well developed, branched, septate mycelium. When these fungi are observed growing on the natural substrata the hyphae are generally contained within the vascular system and only the sporophores and spores are seen; in nature the hyphae are colorless, in culture, however, pigments are produced by many of the species which either accumulates in the mycelium or diffuses out into the surrounding medium or both. The sporophores are simple or branched, more or less distinct from the mycelium, scattered and colorless, both in nature and in culture. In culture, depending upon the species, the sporophores may also be produced in dense clusters or tufts on sclerotia. The spores are one- to many-celled, branched or unbranched, and colorless, both in nature and in culture. Secondary fruiting bodies, pycnidia or sporodochia, were never observed in nature and were infrequent in culture.

There are now seventeen genera of the Fungi Imperfecti represented in the fresh-water flora of Britain and the United States; eleven of these genera have been added since 1940. Of the described genera and species of the aquatic Hyphomycetes, only six of the genera, *Varicosporium*, *Clavariopsis*, *Lemonniera*, *Tetracladium*, *Heliscus* and *Dactylella* have been placed in taxonomic keys and until recently two of them, *Heliscus* (Ingold, 1942) and *Dactylella*, were represented by terrestrial species only. Thus it is felt that a systematized arrangement of the genera of all the Hyphomycetes having aquatic species would be valuable in the identification of those genera that have never before been placed in such a key.

KEY TO GENERA OF THE FRESH-WATER AQUATIC FUNGI IMPERFECTI

I. Spores aleuriospores
  A. Aleuriospores not branched
    1. Aleuriospores released by a rounding off process
      a. Aleuriospores clavate to limoniform to fusiform-eliptical ..... *Dactylella*
      b. Aleuriospores scolecosporus, sigmoid or falcate ..... *Anguillospora*
    2. Aleuriospores released by breakdown of separating cells
      a. Aleuriospores continuous with the aleuriophore, scolecosporus, sigmoid or falcate ..... *Anguillospora*
      b. Aleuriospores borne on stalk-cells on tips of aleuriophores; stalk-cells attached at a point some distance from either end of the spores; spores lunate or sigmoid ..... *Lunulospora*
  B. Aleuriospores branched
    1. Branches formed in succession
      a. Branches four or more
        (1). Aleuriospores dendroid with elongated main axes and secondary and tertiary branching ..... *Dendrospora* (not treated)
        (2). Aleuriospores of four divergent branches only ..... *Articulospora*
        (3). Aleuriospores of four divergent branches and one or more subspherical or oblong knobs situated at or near the point of divergence ..... *Tetracladium*
      b. Branches three or less
        (1). Aleuriospores consist of elongated axes, two or three lateral branches situated at different levels on the main axes ..... *Tricladium*
        (2). Aleuriospores consist of elongated axes, three divergent branches from the same level at the lower end of the axes ..... *Tricelophorus*
    2. Branches formed simultaneously
      a. Aleuriospores symetrical
        (1). Aleuriospores with clavate axes and three divergent branches from the apices ..... *Clavariopsis*
        (2). Aleuriospores with elongated filiform axes and two divergent branches midway on axes; spores shed by breakdown of separating cells ..... *Tetrachaetum*
      b. Aleuriospores asymmetrical, each consists of a large central cell with two divergent appendages and a lateral branch with two appendages ..... *Campylospora*

II. Spores conidia
  A. Conidia formed on phialides
    1. Conidia not branched
      a. Conidia spherical, tetrahedral or broadly fusiform ..... *Margaritispora* (not treated)
      b. Conidia scolecosporus, sigmoid ..... *Flagellospora*
    2. Conidia branched
      a. Branches develop simultaneously
        (1). Conidia clavate with three divergent branches at the apices ..... *Heliscus*
        (2). Conidia consist of elongated axes with two lateral branches inserted side by side midway on the axes ..... *Alatospora*
        (3). Conidia consist of four divergent branches only, inserted on the phialide at the point of juncture of the branches ..... *Lemonniera*
  B. First formed and terminal conidium only borne on a phialide, others pleurogenous

1. Conidia consist of elongated axes with two or three lateral branches on one side of the axis; tertiary branches from the laterals also one-sided..... ..... *Varicosporium* (not treated)

DESCRIPTION AND DISCUSSION OF SPECIES

The discussion will be concerned with the morphology, including the phases of development of the spores from their initiation to maturity and release, and the behavior of these fungi in culture. At the end of the general discussion of each species, a short summary of the diagnostic characters will be given which will include only such characters as have been observed on the natural substrata. Since *Anguillospora longissima* (Sacc. & Syd.) Ing., *Clavariopsis aquatica* De Wild., *Lemonniera aquatica* De Wild., *Tetracladium marchalianum* De Wild., and *T. setigerum* (Grove) Ing. are better known than the other species and have been discussed in detail more than once in the past, they will be given only the most generalized treatment.

All drawings were made with the aid of a camera lucida from hanging-drop cultures prepared either from bits of agar strips from pure culture or from bits of decaying leaf material taken from nature.

DACTYLELLA AQUATICA (Ing.) n. comb.

Though Ingold (1943) described this fungus under the binomial *Piricularia aquatica*, he was not at all certain that his choice of a genus was a good one. The reasons for transferring this species to the genus *Dactylella* will be discussed later in the section.

A fungus (Figs. 1 L, 2) differing, if at all, in few details from the organisms described and figured by Ingold was found on a skeletonized leaf collected by Dr. Lee Bonar in August of 1949 from the Klamath River in southern Oregon close to the northern boundary of California.

The unbranched sporophores are ordinarily short, usually no longer than 65 mu though an occasional sporophore will attain a length of 200 mu. The first spore, a truly terminal structure, is initiated by the formation of a clavate swelling at the tip of the sporophore (Fig. 2 C). The swelling is soon delimited from the sporophore by a transverse septum (Fig. 2 E). As the spore primordium continues to develop, the clavate form changes gradually to a limoniform one. During this change, a septum is usually formed somewhat below the region of greatest width (Fig. 2 F). A second septum is frequently formed just above the region of greatest widts as well, but ordinarily the spore is shed in the unequally two-celled condition. The spores often become three- or four-celled after they are shed but before germination. The spore, clearly an aleuriospore by Vuillemin's definitions, is shed by a gradual disarticulation and rounding off process at the basal septum.

As soon as the first spore is shed, a second is initiated in one of two observed ways. In the first, the process is like that described by Ingold, i.e., a slight elongation of the sporophore slightly to one side of the tip. Thus, after a series of spores, the sporophore may become somewhat scorpioid with barely discernible scars. In the second, the sporophore elongates through the scar left by the first spore (Fig. 2 B, D, H) and then a new spore is formed. Thus after a series of spores, the sporophore is similar in appearance to that of a Fusicladium sporophore with barely discernible circumscissile scars.

The fungus was isolated in pure, single-spore culture several times from the one collection made. On malt agar it formed a compact colony that was at first white

and then, as it aged, became greenish-grey. After attaining a diameter of three or four centimeters, the colony became markedly zonate with alternating rings of greenish-grey and white mycelium. The thin, fluffy aerial mycelium also became greenish-grey. Also as the culture aged, the agar became yellow. At first this coloration was visible only in the center of the colony but soon the entire plate or slant became yellow. At no time were the fuscous aerial spores observed such as those described by Ingold. Since it is only during a very brief period that the brown aerial spores are produced, and since the American material agrees so closely with the fungus Ingold described, it is possible that the spores were formed and overlooked. When a slice of the colony was placed in water, perfectly normal sporophores and spores were formed. The spores germinated readily in water or on malt agar and behaved like those isolated from nature.

Whether Ingold is correct in his selection of a genus for this species or not, it is clear the fungus he collected and described and our fungus are the same species. As Ingold (1943, 1944) has pointed out this fungus is difficult to classify. The difficulty arises not so much from the fuscous vs. the colorless aquatic spores, which is a relatively minor matter, but from the nondescript nature of the sporophore and the generalized character of the spores. A case could be made for assigning this species to any one of a number of genera, viz., *Monacrosporium* Oud., *Ramularia* Sacc., *Dactylella* Grove as well as *Piricularia* Sacc.

When the original descriptions of the two best genera, *Piricularia* (Saccardo, 1880) and *Dactylella* (Grove, 1884), are consulted there seems to be little to choose between them. *Piricularia* was described as follows: "Hyphae biogenae subsimplices; conidia obclavato-pyriforma, 2 - pluriseptate, solitarie acrogena." *Dactylella*, on the other hand, was described as "Mucedinea, macronemea, saprophila. Hyphae fertilis erectiusculae, simplices. Sporae elongatae, solitarie acrogenae, pluriseptatae."

Though the chief differences between them, as described, are the habit and the shape of the spores, actual practice has tended to delineate these two genera more sharply. *Piricularia* has come to encompass those parasitic fungi (some species have been induced to produce spores in culture) with generally simple sporophores and acrogenous, obclavate, septate spores with a small abscission collar. *Dactylella* has come to encompass nematode-attacking (Drechsler, 1947, 1950) as well as those saprophytic fungi with simple sporophores bearing a single acrogenous phragmospore or several in succession; the spores in general vary from limoniform to fusiform-elliptical and may be two- to many-celled.

Since the species concerned is a saprophytic organism with simple sporophores bearing several acrogenous, limoniform spores in succession that have one or two transverse septa and no evidence of a basal abscission collar, it is proposed that this species be removed from the genus *Piricularia* and placed in the genus *Dactylella* as *D. aquatica* (Ing.) n. comb.

Dactylella aquatica (Ing.) n. comb.

Piricularia aquatica Ing., *Trans. Brit. Myc. Soc.*, Vol. XXVI, 107:1943.

Submerged aquatic fungus with branched, septate, colorless mycelium. Aleuriophores 15–65 mu long, 2.5–3.5 mu broad, simple, colorless. Aleuriospores limoniform, colorless, 20–30 mu long, 8–13 mu broad at the widest point; when uniseptate the septum is near the base, when biseptate the septa are near each end with the largest cell in the middle; aleuriospores produced in succession, first formed one truly terminal, secondary ones produced by scorpioid elongations of the aleuriophore or by terminal elongations, scars of former aleuriospores remaining.

ANGUILLOSPORA LONGISSIMA (Sacc. & Syd.) Ing. and ANGUILLOSPORA PSEUDOLONGISSIMA n. sp.

Anguillospora longissima was found throughout the year on a wide variety of submerged and decaying angiosperm debris. It is very common in California and

has been found in almost every collection. It is frequently the dominant fungus on the substratum.

De Wildeman (1893) collected and described a fungus under the binomial *Fusarium elongatum*. Since he was unable to culture it or find stages in the development of it other than the sickle-shaped spores and some faintly pigmented mycelium, the genus *Fusarium* seemed like a good choice. Saccardo and Sydow (1899) changed the name to *F. longissimum* since the specific epithet applied by De Wildeman had already been preempted. Ingold (1942) was the first to study the development and release of the spores as well as the first to culture it. He found that the spores, unlike those of a *Fusarium*, were aleuriospores and in addition were released by the breakdown of a specialized separating cell (Fig. 1 A). On the basis of the separating cell and the fact that the spores are aleuriospores whereas the spores of *Fusarium* are phialospores, Ingold made this fungus the type of a new genus, *Anguillospora*.

Anguillospora longissima (Sacc. & Syd.) Ing., *Trans. Brit. Myc. Soc.*, Vol. XXV, 389: 1942.

Fusarium elongatum De Wild., *Ann. Soc. Belge Microsc.*, Vol. XVII, 40:1893.
Fusarium longissimum (De Wild.) Sacc. & Syd., *Syll.*, 1128:1899.

Submerged aquatic fungus with branched, septate mycelium, colorless. Aleuriophores simple or sparingly branched, colorless, bearing at the tips one spore. Aleuriospores terminal, colorless, sigmoid or falcate, scolecosporus, 150–350 mu long, 5–6 mu broad in the middle and tapering to 2.5–3 mu at the tips, 6–10 or more cells; separating from the aleuriophores by the breakdown of special separating cells at the ends of the aleuriophores.

That this fungus is not a *Fusarium* is clearly evident. That the separating cell is a good generic character is not so evident. A number of isolates, apparently of this species, were found to release their spores by a disarticulation and rounding off process at one of the septa near the end of the sporophore (Fig. 1 T). These isolates were otherwise but little different from the fungus described by Ingold. On malt agar they produced a dense whitish colony that soon became brownish- or greenish-black with a narrow white margin. No spores were formed aerially, but when a slice of the colony was placed in water, spores were produced in fairly large numbers on simple or branched sporophores more clearly differentiated than those of *A. longissima*. Only one spore was produced on each simple sporophore or on each branch. The spores germinated within a very few hours in water or on malt agar.

Thus, save for the absence of the separating cell, these fungi fit the generic characters for *Anguillospora* as established by Ingold. Rather than create a new genus on what seems to be only a species category, especially in view of the fact that Ingold himself (1949) has added a species without a separation cell to this genus, it is proposed that the genus *Anguillospora* be expanded to include these forms.

Anguillospora Ing.

Submerged aquatic fungi with branched, septate mycelium. Aleuriospores terminal, eel-like, septate, colorless, either separating from the aleuriophore by the breakdown of a separating cell or by a disarticulation and rounding off process at a septum at the end of the aleuriophore.

Anguillospora pseudolongissima n. sp. (Figs. 1 T, 3 A)

Submerged aquatic fungus with branched, septate mycelium, colorless. Aleuriophores branched or sometimes simple, colorless, 50–150 mu long, 3.5–4.5 mu broad. Aleuriospores terminal, colorless, sigmoid or falcate, scolecosporus, 50–100 mu long, 4.6–6 mu broad in the middle and tapering to 3–5 mu at the tips, 5–8 celled. Aleuriospores shed by a gradual disarticulation and rounding off process at one of the septa at the end of the aleuriophores.

Hab. On decaying and submerged leaves of *Salix* sp. in a creek near Bishop, Mono County, California.

Anguillospora pseudolongissima sp. nov.

Fungus aquaticus submersus, a mycelio ramoso septato, sine colore. Aleuriophorae sine colore, ramosae vel subinde simplices, 50–150 mu longitudine, 3.5–4.5 mu latitudine. Aleuriosporae acrogena, sine colore, sigmoideae vel falcatae, scolecosporae, 50–100 mu longitudine, medio 4.5–6 mu latitudine, utrinque ad 3–4 mu attenuatae, 5–8 cellulatae. Aleuriosporae a disarticulatione gradata parietis et turgescente cellularum contra septum aliquem apices aleuriophore.

Hab. In foliis submersis putrescentibusque *Salicis* sp. in rivulo prope Bishop, Comitate Mono, California.

For both *Anguillospora longissima* and *A. pseudolongissima*, colonies, arising from single-spore isolations, have produced some secondary sporulating structures. The exact nature of these is as yet in doubt. In certain cultures of *A. longissima* black pycnidia, 75–100 × 90–120 mu, of an irregular but globose shape, were found. The pycnidiospores formed were colorless oblong bodies measuring 2–2.5 × 3–3.5 mu. In certain cultures of *A. pseudolongissima* colorless phialides and phialospores were produced (Fig. 3 A). The phialides were flask-shaped; the venter at its widest diameter was about 4 mu and narrowed to about 1.5 mu at the neck. The phialides, when first formed, were without the neck-like portion. As the development proceeded a small protuberance would be formed which gradually elongated until an oblong structure, 2–2.5 × 6–6.5 mu, was produced above a narrow constriction which formed the neck. The wall at the apex of the oblong structure gave away and an oblong phialospore was extruded abruptly into the water. After the release of the first phialospore had taken place, another began its development in the bottom of the tube formed by the wall of the tip of the phialide after the release of the first phialospore.

It was thought that the phialospores and pycnidiospores were spermatia. However, matings between the two species and between different single-spore isolations of each species collected from several localities also proved unsuccessful. All attempts to germinate the phialospores and pycnidiospores were also unsuccessful.

ANGUILLOSPORA GIGANTEA n. sp.

This species (Figs. 1 K, 3 B–G) was found only during the summer and early fall months on submerged and decaying cottonwood leaves and twigs. It does not appear to be a common species, and while it has been collected many times during this survey, it has only been found in the one locality. The simple sporophores, up to 65 mu in length, grow out into the water at right-angles from the veinlets of the leaves, either scattered or in dense tufts. Differentiation between the mycelium and the sporophore on one hand and the sporophore and the spore on the other is very difficult; these structures gradually blend into one another.

The spore begins its development as a slight swelling of the sporophore tip; it enlarges from 2.5 mu near the base to 5–6 mu near the tip and forms the spore primordium. Very early in its development, the spore primordium is delimited by a transverse septum (Fig. 3 B). As the spore primordium elongates, with growth more or less restricted to the terminal portion, cross-walls are formed and a curvature of the spore is brought about by the activity of the growing tip. The curvature is not always restricted to one plane so that when the spore is mature it is more or less sigmoid but generally less so than the spore of *A. longissima*. The spore is composed of six to ten cells, varies in length from 150–750 mu or more and is 5–6 mu in width in the middle and tapers gradually to 2.5–3 mu at the tips. The spore is shed in the same manner as *A. pseudolongissima*. There is only one spore, clearly an aleuriospore, formed on each sporophore.

The fungus was isolated in pure, single-spore culture. On malt agar a dense colony was formed with a thick cottony aerial mycelium. Shortly after the colony was established a very pronounced dark red pigment appeared and as the colony aged became a deep reddish-purple. Microscopic examination showed that the walls of the older hyphae were colored a reddish-brown and that the agar itself was stained purple. The aerial hyphae were less pigmented and appeared light pink in color. This pigment has not been observed in nature.

Aleuriospores are not produced on agar. When, however, a narrow slice of the agar colony was placed in water, aleuriospores were formed in great numbers in twelve to twenty-four hours on aleuriophores that arose from the cut surfaces of the older portions of the colony. The spores produced in culture were similar in every way to those formed in nature, except that the spores were generally shorter (150–300 mu) than those formed on the natural substratum. In culture irregular sclerotium-like bodies, formed of thick-walled and heavily pigmented hyphal cells were developed. When the sclerotia were placed in water a loose sporodochium was formed on each and large numbers of spores produced. The aleuriospores germinated readily in water or on malt agar and germ-tubes were formed by any or all of the cells of the spore.

Anguillospora gigantea n. sp.

Submerged aquatic fungus with branched, septate, colorless mycelium. Aleuriophores simple, colorless, up to 65 mu long, 2.5 mu wide, bearing only one aleuriospore. Aleuriospores terminal, colorless, sigmoid or falcate, scolecosporus, 150–750 mu long, 5–6 mu broad in the middle and tapering gradually to 2.5–3 mu at the tips, 6–10 celled; shed by a disarticulation and rounding off process of one of the terminal septa of the aleuriophore.

Hab. On decaying and submerged leaves and twigs of *Populus* sp. in an irrigation ditch near Walnut Creek, Contra Costa County, California.

Anguillospora gigantea sp. nov.

Fungus aquaticus submersus, mycelio septato, sine colore. Aleuriophorae sine colore, simpliciae, ad 65 mu longitudine, 2.5 mu latitudine, sporam unicam ferens. Aleuriosporae acrogenae, sine colore, sigmoideae vel falcatae, scolecosporae, 150–750 mu longitudine, medio 5–6 mu latitudine utrinque attenuatae gradatim ad 2.5–3 mu, 6–10 cellulatae; a disarticulatione turgescenteque cellularum ad aliquem cellulam terminalem sporophorae contiguarum liberatae.

Hab. In foliis et ramulis submersis putrescentibusque *Populi sp.* in fossa irrigationis prope Walnut Creek, Comitate Contra Costa, California.

LUNULOSPORA CURVULA Ing.

Ingold (1942) first described this beautiful fungus (Figs. 1 V, 4 A–I) as the type and only species in his new genus *Lunulospora*. It has been found throughout the year and throughout the state of California especially during the spring and summer months.

The sparingly branched or occasionally simple sporophores project from the petioles and larger veins of the rotting leaves into the water and attain a length of 75–250 mu. The sporophore may have two or three branches, and at the tip of each branch it may bear three or four spores in varying stages of development. Spore formation is initiated by the production of a clavate cell some 12–14 mu in length and 2–4 mu in width that is soon delimited from the sporophore by a basal septum (Fig. 4 A, B). Shortly after the clavate cell is cut off, another septum forms 2–6 mu above the first one (Fig. 4 C). The upper cell is the spore primordium and the lower or stalk-cell behaves like the separating cell of *Anguillospora longissima* when the spore is mature. The spore primordium elongates by means of apical

growth. When the spore primordium has about doubled its length, a second growing point differentiates at the base of the spore primordium and to one side of the place where the stalk-cell joins the body of the spore (Fig. 4 E–G). Both growing points elongate by means of apical growth but not always in the same plane so that a sigmoid crescent, 65–90 mu in length and tapering to 0.5–1 mu at the tips, is the result. The spore, clearly an aleuriospore is unicellular. At maturity the stalk cell breaks down and the spore is released.

While the first spore is developing on the sporophore tip, a second and third spore are often produced alongside the first and truly terminal one. This may be repeated several times and the apex of the sporophore takes on a clavate or platform appearance and may reach a width of 8–10 mu and support as many as five or six spores in various stages of development.

The fungus has been isolated several times in single-spore, pure culture. On malt agar a rather dense white colony was produced with little aerial mycelium. As the cultures aged, the older regions became a dark olive green or greenish-black in a very irregular manner, and the cultures sectored readily. Aleuriospores are not formed on agar. Abundant spore formation, however, occurred in twelve to twenty-four hours from the surfaces of a narrow strip of the agar colony that had been placed in water. These aleuriospores and aleuriophores were morphologically similar in every way to those formed in nature. After the fungus has been in culture for a few weeks, it has a tendency to become sterile. At first the spores isolated from culture would germinate readily in water or on malt agar; later on the spores would not germinate and still later spore production was considerably reduced and finally ceased altogether.

Lunulospora curvula Ing., *Trans. Brit. Myc. Soc.* Vol. XXV, 404:1942.

Submerged aquatic fungus with branched, septate, colorless mycelium. Aleuriophores simple or sparingly branched, 75–250 mu long, 3–4 mu broad. First aleuriospore truly terminal in linear extension of the aleuriophore, subsequent spores on an expanded apex of the aleuriophore. Aleuriospores colorless, lunate, sigmoid, unicellular, 65–90 mu long, 5–6 mu broad at the point of attachment, tapering to 0.5–1 mu at the tips; attached to a stalk cell at a point along the convex surface; liberated by the dissolution of the stalk-cell.

ARTICULOSPORA TETRACLADIA Ing.

This fungus (Figs. 1 P, 5 A–G), the type species of the genus, was originally collected and described by Ingold (1942). It has been found in California from late spring through early fall on a wide variety of submerged decaying angiosperm debris. It was not, however, found in abundance. It may have been overlooked due to the superficial resemblance of its spores to those of several other species, viz., *Lemonniera aquatica*, *L. cornuta*, and *Tricelophorus monosporus*. The short sporophores, hardly 40 mu in length, were more often than not hidden by the growth of diatoms and other microorganisms so that it was usually only the spores that were observed. It was collected more by accident than by design. The studies were made on pure cultures of the fungus obtained by single-spore isolations.

On malt agar the colony consisted of a dense buff colored mycelial mat with a thick white or greyish aerial mycelium in large scattered tufts. Spores were formed only when a piece of the colony was placed in water.

The spore primordium, the first formed branch of the spore, is initiated by the cutting off by a septum of a terminal portion of a sporophore or a branch (Fig. 5 B, D). From the apex of the spore primordium the second branch of the spore is initiated much like the "bud" of a yeast cell (Fig. 5 B, C). The second branch, separated from the first by an isthmus and then by a septum is in the beginning on a straight line with the first. Close to the point of origin of the second branch and slightly to one side a new cell is budded out on the first branch (Fig. 5 D). As the

third branch develops it displaces the second to one side so that at this stage the spore resembles a "Y." While the elongation of the second and third branches proceeds, the fourth is initiated in the same manner as the other two and more or less between the second and third branches (Fig. 5 E). The fourth branch in its development displaces to one side the third. Thus the mature spore consists of four divergent branches of which the second, third and fourth are separated from the first by narrow isthmuses and usually a septum as well. Ordinarily the branches become once or twice septate, particularly the first and second, before the spore is shed.

Usually, while the first spore is developing, a new spore is initiated in a bud-like fashion beside the original one; the process of development of the second spore is in no way different from the first. This process may be repeated indefinitely. Often, in culture, the second or third spore "bud" may develop into a lateral branch of the sporophore and become several cells in length, then the terminal cell becomes the spore primordium. The spores are liberated by disarticulation at the basal septum (Fig. 5 C, G). The spores are clearly aleuriospores.

Articulospora tetracladia Ing., *Trans. Brit. Myc. Soc.*, Vol. XXV, 327: 1942.

Submerged aquatic fungus with branched, septate, colorless mycelium. Aleuriophores simple or sparingly branched, colorless, up to 40 mu long, 3–4 mu wide. Aleuriospores terminal, colorless, composed of four divergent branches; the first branch 17–25 mu long, 3–5 mu wide, 2–3 celled; the other three branches, of more or less equal length, 20–50 mu long, 3–4 mu wide, tapering to a narrow point, each separated from the first branch by a narrow isthmus 1.5 mu wide. The four branches arise in succession. Aleuriospores produced in succession from the tips of the aleuriophore and its branches but not basipetally.

ARTICULOSPORA MONILIFORMA n. sp.

In the spring of 1947 in Calaveras County and again in the summer of 1949 in Sonoma County a different species of *Articulospora* (Figs. 1 N, 9 A–G) was found on submerged and decaying alder and willow leaves. This species was not very abundant on the leaves and has been collected only a few times. It is quite possible that *A. moniliformа* was overlooked for the same reasons that *A. tetracladia* was. The branched sporophores, often quite short and at most hardly exceeding 50 mu in length, were generally obscured by the growth of diatoms and other microorganisms. The fungus was successfully isolated several times in single-spore, pure culture and all observations were made on pure culture material.

On malt agar the fungus formed a dense, compact, dull orange colony with no cottony aerial mycelium. The surface growth consisted of a firm crust or a series of irregular small crusts of densely packed, intertwined globose hyphal cells filled with oil globules and small granules that apparently gave the colony its characteristic color. Spores were produced only when bits of the colony were placed in water. The spores and sporophores were identical with those found in nature. The spores followed the same basic pattern of development as *A. tetracladia*, but the sporophore and spore morphology were different.

The main axis of the sporophore is little differentiated from the vegetative hyphae. The distal portion of the axis and all of the lateral branches are composed of conspicuously clavate cells 10–15 mu in length and 5–6 mu in width at the distal ends and taper to 2.5 mu at the point of contact with the cells below them. Occasionally the individual cells are globose at both ends with a relatively narrow isthmus between the swollen portions.

The formation of the aleuriospores and the sequence of development of the branches are like those of *A. tetracladia*. The aleuriospores, however, are markedly smaller than those of either *A. tetracladia* or *A. inflata*. All four of the branches of *A. moniliformа* are more nearly alike in size and shape than are those of *A. tetracladia*. While the second, third and fourth branches of *A. tetracladia* are somewhat obclavate

and are separated from the first formed one by narrow isthmuses, the first formed branch of *A. moniliforma* is conspicuously clavate and the other three are equally conspicuously obclavate. The proposed specific epithet was suggested by the pronounced swelling of the cells of the branches of the aleuriophore and of the unicellular branches of the aleuriospores which gives to the whole sporulating apparatus a beaded appearance.

Articulospora moniliforma n. sp.

Submerged aquatic fungus with branched, septate, colorless mycelium. Aleuriophores branched, colorless; lower unbranched portion 25–30 mu long, 2–2.5 mu broad; upper branched portion composed of clavate cells, 10–15 mu long, 5–6 mu wide tapering to 2.5 mu at the base. Aleuriospores terminal, colorless, composed of four divergent branches; first formed branch clavate, 13–16 mu long, 2.5–4 mu wide at greatest width; second, third, and fourth branches obclavate, 10–16 mu long, 3–4 mu wide, tapering to 1.5 mu at the tips, separated from the first branch by narrow isthmuses. The four branches arise in succession. Aleuriospores produced in succession at or near the tips of the aleuriophores but not basipetally.

Hab. On submerged and decaying leaves of *Salix* and *Alnus* spp. Stanislaus River, Calaveras County, California.

Articulospora moniliforma sp. nov.

Fungus aquaticus submersus, a mycelio ramoso, septato, sine colore. Aleuriophorae ramosae, sine colore, infra simplices, 25–30 mu longitudine, 2–2.5 mu latitudine, pars superiora aleuriophorae ramosae, compositae a cellulis clavatis, 10–15 mu longitudine, 5–6 mu latitudine ad basis attenuatis ad 2.5 mu. Aleuriosporae acrogenae, sine colore, a radiis divergentibus, radio primario clavato, 13–16 mu longitudine, 2.5–4 mu latitudine maxima, radiis certeris obclavatis 10–16 mu longitudine, 3–4 mu latitudine, utrinque attenuatis ad 1.5 mu a conjunctis cum radio primario constrictis, radiis quattuor ex ordine evolutis. Aleuriosporae ad apices ramulorum aleuriophorae prope limdem locim deinceps evolutae.

Hab. In foliis submersus putrescentibusque *Salicis* sp. et *Alni* sp. flumine Stanislaus, Comitate Calaveras, California.

TETRACLADIUM MARCHALIANUM De Wild. and T. SETIGERUM (Grove) Ing.

Tetracladium marchalianum De Wild. (Fig. 1 F) and *T. setigerum* (Grove) Ing. (Fig. 1 G) are probably the most common aquatic Hyphomycetes found in California. They are frequently found together on the same substratum in large numbers and in addition to a wide variety of angiosperm debris may be found on such substrata as *Marsilia* and decomposing *Isoetes*.

Tetracladium marchalianum De Wild. *Ann. Soc. Belge Microsc.*, Vol. XVII, 34:1893.

Cerasterias raphidioides Reinsch var. *inaequale*, *Notarisia*, Vol. III, 512:1888.

Submerged aquatic fungus with branched, septate, colorless mycelium. Aleuriophores simple or branched, bearing one to several aleuriospores at the tips in various stages of development. Aleuriospores consisting of four divergent branches up to 25 mu long, 2–3 mu wide at the base, tapering gradually to a point, and two knobs, more or less spherical or oblong, one- or two-celled, 2.5–5 mu broad and up to 6 mu long. One of the knobs is situated in the axil of the four branches and the other, usually the smaller, some distance out on a branch on the upper surface.

Tetracladium setigerum (Grove) Ing., *Trans. Brit. Myc. Soc.*, Vol. XXV, 369:1942.

Cerasterias raphidioides Reinsch var. *incrassata*, *Notarisia*, Vol. III, 512:1888.

Tridentaria setigera Grove, *J. Bot.*, Vol. L, 16:1912.

Submerged aquatic fungus with branched, septate, colorless mycelium. Aleuriophores simple or branched, bearing one to several aleuriospores at the tips in various stages of development. Aleuriospores consisting of four divergent branches up to 35 mu long, 3 mu broad at the base, tapering to about 1 mu at the tips, and three knobs, fusiform-elliptical, 13–15 mu long, 2.5–3 mu wide, two- to three-celled. Two of the knobs situated in the axil of the branches and the other some distance out on the upper surface of one of the arms.

TRICLADIUM SPLENDENS Ing.

This species (Figs. 1 U, 7 A–G) and type of the genus was found by Ingold and described by him in 1942. Though the fungus is a common one in England, it has been collected only four times in California and appears to be one of the rarer species in this locality.

The sporophores are little differentiated from the vegetative hyphae and are up to 65–75 mu in length. The spore primordium is formed when the terminal, clavate portion of a sporophore is delimited by a transverse septum (Fig. 7 A). The spore primordium increases in size by apical growth and forms the curved main axis of the spore. When the spore primordium is at the two- or three-celled stage, a lateral branch is initiated just below one of the septa (Fig. 7 C). The branch, at first similar to the "bud" of a yeast cell, enlarges laterally and elongates by apical growth more or less perpendicular to the main axis and tapers gradually to a point. The lateral branch, 32–60 mu in length and 5 mu broad near the base, is separated from the main axis of the spore by a narrow isthmus less than 2 mu in width. Not long after the initiation of the first lateral, a second branch is formed in the same manner as the first and usually from the next cell of the main axis (Fig. 7 E). The two lateral branches, though both originating on the convex side of the main axis, are not in the same plane and are somewhat divergent. The lateral branches usually become two- or three-celled. The mature spore, then, consists of a main axis that is more or less curved and two divergent branches separated from each other by a linear distance of some 15–20 mu, and each branch is separated from the main axis by a narrow isthmus. The spore, an aleuriospore, is shed by the disarticulation of the first formed septum usually and by the rapid rounding off of the cells on either side. Only one spore is produced on an aleuriophore or on each branch.

Tricladium splendens was isolated several times in pure, single-spore culture. The spores germinated readily in water and on malt agar; germ-tubes were generally produced from the tips of the branches and from both ends of the main axis though frequently other cells cooperated. On agar, almost from the first, a dense brownish-black colony was developed with a narrow white border; the colony was frequently inconspicuously zonate. Spores were not formed on agar but when a slice of the colony was placed in water, spores were produced in fair abundance in twenty-four to thirty-six hours. The majority of spores, in culture, agreed with those found in nature. Sometimes, however, large numbers of abnormal spores were developed, i.e., spores with only one branch so that a "Y"-shaped object resulted or spores without any branches. The abnormal spores, when cultured, produced colonies indistinguishable from those of normal spores and when placed in water the spores obtained behaved like those of the original isolates.

Tricladium splendens Ing., *Trans. Brit. Myc. Soc.*, Vol. XXV, 385:1942.

Submerged aquatic fungus with branched, septate, colorless hyphae. Aleuriophores colorless, usually simple, 30–74 mu long, 3–4 mu wide. Aleuriospores terminal, colorless, consisting of an elongated curved main axis, 2–5 septate, 50–100 mu long, 5–6 mu broad, tapering to 3 mu at the tips, and two divergent branches arising from the convex side of the axis in different planes. Branches 15–20 mu apart, 32–60 mu long, 5 mu wide near the base and tapering to 1–2 mu at the tips, each separated from the main axis by a narrow isthmus less than 2 mu wide. Aleuriospores

shed by disarticulation and rounding off of the cells on either side of one of the lower septa. Only one aleuriospore is produced on the aleuriophore or its branches.

TRICLADIUM ANGULATUM Ing.

The second species of the genus (Figs. 1 B, 7 H–N), first described in 1942 by Ingold, was collected throughout the year in California. It was most frequently found from February through July and less commonly at other times. It is a very common fungus and often forms miniature forests of sporophores and spores over the surface of the substratum.

The sporophores range from simple ones to those with four or five branches and even the simple ones, after a time, become branched. The first formed spore, either on the main axis of the sporophore or on a branch, is truly terminal. A clavate extension of the sporophore is cut off by a transverse septum some 30–40 mu back from the tip and becomes the spore primordium (Fig. 7 H); it may at this time be already slightly curved or even sigmoid. Shortly afterwards a second septum is formed which cuts the primordium roughly in half. While the primordium continues to elongate by apical growth, an arm or branch is formed on the convex side of the spore axis and usually just below this second septum. Since this branch has a wide-angle base, the already curved spore axis is sharply bent at this point (Fig. 7 J–K). As development continues, another transverse septum is formed above the second, and just below this septum a second branch is initiated. The second branch, usually in a different plane from the first, has the same effect on the main axis as the first branch (Fig. 7 L). Thus the main axis of the spore is scorpioid and has two arms, not in the same plane, attached by a wide base (Fig. 7 M). The spore is released in the same fashion as *T. splendens*.

While the first spore is developing, a new clavate extension of the sporophore forms alongside it. The course of events followed during the maturation of the second spore is like that of the first. This process may be repeated several times so that at any one time, on any one sporophore, a number of spores in various stages of maturation may be found. The sporophore during this process takes on the same clavate or platform appearance of *Lunulospora curvula*. The spores are clearly aleuriospores.

The fungus has been isolated in pure, single-spore culture many times. The spores germinate readily in water or on malt agar. Germ-tubes were produced from the tips of the branches and the extremes of the main axis. A compact, creamy-white colony with no aerial mycelium was formed on agar. Spores were formed only when slices of the colony were placed in water; spore formation occurred in about twelve hours. Abnormal spores with only one branch, or no branches at all were occasionally formed in culture but germinated and formed colonies like the normal ones.

Tricladium angulatum Ing., *Trans. Brit. Myc. Soc.*, Vol. XXV, 389:1942.

Submerged aquatic fungus with branched, septate, colorless mycelium. Aleuriophores colorless, simple to sparingly branched, 60–100 mu long, 3 mu wide. Aleuriospores terminal, colorless, branched, each consisting of a main axis, 45–60 mu long, 4–5 mu wide, tapering to about 2.5 mu at the tips and bent into an obtuse angle at the point of juncture of each branch. The two branches are not in the same plane. 25–35 mu long, 6 mu broad at the base and tapering to 2.5 mu at the tips and inserted on the main axis some distance apart. Aleuriospores produced in succession but not basipetally and shed by the disarticulation of the basal septum.

TRICLADIUM GRACILE Ing.

Though this species (Figs. 1 M, 8 A–E) is described by Ingold (1942) as being common in Britain, it is one of the rarer species in California. It was found only a few times during the winter and spring months and never in abundance.

The development of the spore, an aleuriospore, is essentially like that of *T. angulatum* and to a lesser extent like *T. splendens*. Though agreeing with the other species in generalities, there are some specific differences and similarities between *T. gracile* on the one hand and *T. splendens* and *T. angulatum* on the other. There is only one aleuriospore on the aleuriophore as in *T. splendens*. The lateral branches of the spore are inserted on the scorpioid main axis by a broad base as in *T. angulatum*. The lateral branches are either equal in width throughout except at the base or only slightly tapering. The aleuriospores are very much larger than they are in either of the other two species.

Tricladium gracile has been isolated several times in single-spore, pure culture. On malt agar the fungus formed a dense, compact mycelial mat that was at first colorless but soon became a very dark greyish-brown with a light brownish aerial mycelium. The colonies were occasionally zonate. Though no spores were formed on agar, spores were formed in large numbers twelve hours after the colony was placed in water.

In some of the two-day-old hanging-drop cultures there was observed some small clusters of phialides grouped at the terminal regions of old aleuriophores or newly produced determinate hyphae; in each case a phialide was terminal (Fig. 8 E). The phialides and phialospores were similar in appearance and identical in behavior to those found in *Anguillospora pseudolongissima*. All attempts to germinate the phialospores failed. It was thought that they might be spermatia which might function when mated with the complementary strain. Using all of the available isolations in mating experiments, negative results were obtained in every case.

Tricladium gracile Ing., *Trans. Brit. Myc. Soc.*, Vol. XXVII, 38: 1944.

Submerged aquatic fungus with septate, branched, colorless mycelium. Aleuriophores simple, colorless, 75 mu long, 2.5 mu broad, bearing one aleuriospore. Aleuriospores colorless, septate, terminal, each consisting of a scorpioid main axis and two lateral branches situated at different levels on the main axis and usually in different planes; main axis 125–200 mu long, 5–6 mu broad between the lateral branches and tapering to 2.5 mu at the base and 1.5 mu at the apex, bent into a broad angle at the point of juncture of each branch; branches straight, generally even, 50–100 mu long, 1.5 mu broad, situated on the main axis 12–30 mu apart. Aleuriospore shed by disarticulation at the basal septum.

TRICELOPHORUS MONOSPORUS Ing.

Originally described by Ingold (1943), this remarkable fungus (Figs. 1 H, 6 A–G) was found most commonly in California during the spring, summer and fall months on submerged and decaying angiosperm debris of all sorts. Though generally uncommon, it was found to occur in great abundance in certain localities and was sometimes the dominant fungus species.

The sporophores, little differentiated from the vegetative hyphae, are usually simple but may be branched once or twice. They vary in length from 20–150 mu and are between 1.5–2 mu in diameter. The initiation of the spore is first apparent in the formation of a small sub-spherical or oval swelling at the tip of the sporophore (Fig. 6 A). The swelling, the spore primordium, is soon delimited from the sporophore by a transverse septum. When the spore primordium becomes obclavate in shape, the beak-like terminal portion is cut off by a cross-wall from the subspherical basal cell (Fig. 6 B). The basal cell, 3.5 mu in width and 4–5 mu in length, undergoes no further increase in size. The terminal cell elongates by apical growth and reaches a length of 30–40 mu and tapers from about 3 mu at the base to about 1.5 mu at the tip. The terminal cell forms one of the four divergent branches of the spore (Fig. 6 D–G). While the terminal cell is still but little elongated, a small bud-like swelling, similar in appearance to the bud of a yeast cell, is formed on the equator or slightly below the equator of the basal cell of the spore primordium (Fig. 6 C).

By enlargement and terminal elongation, the bud becomes one of the three downward-directed branches of the spore. Shortly after the first branch is initiated and its elongation begun, a second bud is formed some 120 degrees away and in the same plane as the first (Fig. 6 D). A third downward-directed branch is initiated last in the same manner as the other two. Shortly after the elongation of the last formed branch is completed, the spore, an aleuriospore, is discharged by the disarticulation and rounding off of the cells on either side of the basal septum. Generally there are several spores produced on the sporophore, though in each case there is a short period of terminal growth of the sporophore following the release of each spore.

The fungus has been isolated in single-spore, pure culture many times. The aleuriospores germinated readily in water and on malt agar. Germ-tubes were formed from the tips of the divergent branches. On malt agar it grew very slowly, the colony at the end of four weeks was scarcely two centimeters in diameter. The colony was compact with no aerial mycelium. The older hyphae took on a dark brown color that was masked in the center of the colony by an ochraceous powdery layer that on examination proved to be spores. These aerial spores were similar in every way to those formed in nature and to those formed when the agar colony was placed in water.

Tricelophorus monosporus Ing., *Trans. Brit. Myc. Soc.*, Vol. XXVI, 148:1943.

Submerged aquatic fungus with septate, branched, colorless mycelium. Aleuriophores colorless, simple or sparingly branched, 20–150 mu long, 1.5–2 mu in diameter. Aleuriospores colorless, terminal, branched, consisting of a main axis and three downward-directed branches arising from a limoniform basal cell; main axis continuous with the aleuriophore, divided into two cells, the basal cell limoniform, 4–6 mu long, 3–3.5 mu wide, the terminal cell tapering from 3–3.5 mu wide to 1–1.5 at the tip, 30–40 mu long. The divergent branches 120 degrees apart arising from the equator of the limoniform cell, 25–30 mu long, 2–2.5 mu broad and tapering to about 1–1.5 mu at the tips, separated from the basal cell by abrupt isthmuses of about 1 mu in diameter. Aleuriospores shed by disarticulation at a basal septum.

CLAVARIOPSIS AQUATICA De Wild.

This beautiful fungus (Fig. 1 R) was first collected and described by De Wildeman in 1895. It apparently escaped further notice until Ingold (1942) collected and figured it. As Ingold remarked, this fungus is extremely common and, excepting possibly *Anguillospora longissima* and *Tetracladium marchalianum*, it proved to be the most common aquatic Hyphomycete found in California. It was found throughout the year in great abundance on all sorts of angiosperm debris. Our fungus does not differ in any respect from that originally described by De Wildeman or from the organism figured by Ingold. Though De Wildeman was unable to secure the fungus in culture, Ingold was successful. He found that many isolates of the fungus produced pycnidia and sclerotia and a series of intergrading types of these structures. His attempts to germinate the minute oval pycnidiospores met with failure. Many of the California single-spore isolates also formed pycnidia and sclerotia. Here, as well, all attempts to germinate the pycnidiospores have failed. Perhaps the pycnidiospores, as perhaps those of *Anguillospora longissima*, are actually spermatia rather than propagating units, however, this aspect was not attacked. Many of the sclerotia, however, when placed in water produced sporophores and spores like those found in nature.

Clavariopsis aquatica De Wild., *Ann. Soc. Belge Microsc.*, Vol. XIX, 197:1895.

Submerged aquatic fungus with septate, branched, colorless mycelium. Aleuriophores colorless, simple, 50–200 mu long, 2–3 mu broad. Aleuriospores terminal, colorless,

consisting of a clavate two-celled main axis, 35–45 mu long, 11–15 mu broad at the apex and tapering downward to 2.5–3.5 mu at the base, and three divergent branches, 40–80 mu long, 2–2.5 mu broad, even, arising equidistant from each other from the truncate apex. Aleuriospores shed by disarticulation at the basal septum, borne in succession but not basipetally.

TETRACHAETUM ELEGANS Ing.

Ingold collected and described this organism (Figs. 1 I, 10 A–F), the type and only species of the genus, in 1942. Though it seems to be one of the common species in England, it is uncommon in California. It was found throughout the year but more often during the spring and summer months.

The sporophores of this fungus are simple, straight, 50–150 mu in length and 2.5–3.5 mu in diameter. The first indication of spore formation is the appearance of a transverse septum in the sporophore some 100 mu back from the narrowly clavate tip of the sporophore (Fig. 10 A–B). The growth in length of the spore primordium is by apical elongation. As maturation proceeds, a relatively large swelling appears on one side of the spore primordium a few microns back from the tip. The swelling causes the tip to be bent to one side (Fig. 10 C); the tip then continues to grow in this new direction. The swelling, now on the convex side, develops into two new growing points of equal size, side by side, on the same level, which make an angle of about 120 degrees with each other and with the tip of the spore (Fig. 10 D). These three growing points continue their apical growth at about the same rate with the spore tip slightly in advance until a tetraradiate spore is produced with a main axis, divided in half, and two branches and all parts of about the same length (Fig. 10 E-F).

Shortly after the initiation of the two secondary growing points a new transverse septum is formed about 5 mu above or below the septum that originally delimited the spore primordium (Fig. 10 E). This cell behaves exactly like the previously described separating cell of *Anguillospora longissima*. When the spore is mature, this cell breaks down and the spore floats away. For a brief period thereafter, a short collar may be seen remaining at the base of the liberated spore, an aleuriospore, and the tip of the aleuriophore (Fig. 10 F). When the spore is shed the spore-producing capacity of the aleuriophore is at an end.

The fungus has been isolated in pure, single-spore culture. The spores germinated readily in water or on malt agar. A number of germ-tubes were produced, usually from either end of the main axis and from the tips of the branches or occasionally several of the cells of the body of the spore cooperated. On malt agar there was formed a dense, creamy-white mycelium with or without a fluffy aerial growth. Spores were produced in culture only when a slice of the agar colony was placed in water. Spore formation was exceedingly abundant under these conditions. The aleuriospores and aleuriophores were identical in every way to those formed in nature.

Tetrachaetum elegans Ing., *Trans. Brit. Myc. Soc.*, Vol. XXV, 337:1942.

Submerged aquatic fungus with septate, branched, colorless mycelium. Aleuriophores simple, colorless, 50–150 mu in length, 2.5–3.5 mu broad, each bearing one aleuriospore. Aleuriospores terminal, colorless, each consisting of a main axis 200–300 mu long, 1.5–2.5 mu wide, 4–6 celled, and two lateral, divergent branches, 100–150 mu long, 1.5–2.5 mu broad, situated side by side midway along the main axis. Aleuriospores released by the breakdown of separating cells 5–6 mu in length at the end of the aleuriophore.

CAMPYLOSPORA CHAETOCLADIA n. gen., n. sp.

In November of 1948 on skeletonized maple leaves from a stream in Sonoma County and again in April of 1949 on a leaf too decomposed to identify from a

melting snow freshet at Mineral, near Mount Lassen National Park, California, a most unusual and interesting fungus was collected (Figs. 1 Q, 11 A–M). The mycelium, like that of all the other fungi in this aquatic group, ramified throughout the secondary and primary veins of the leaves and only the sporophores and spores were visible.

The sporophores are very short, 10–20 mu in length and 2–2.5 mu in diameter; the sporophores, unbranched, appear to be no different from the vegetative hyphae. A short clavate swelling, some 10 mu in length, appearing at the tip of the sporophore, is the first indication of the spore primordium (Fig. 11 B). The clavate tip soon becomes conspicuously pyriform at which time the delimiting septum appears between the spore primordium and the sporophore (Fig. 11 C). Further enlargement of the spore primordium is in a lateral direction so that it soon resembles very closely the "crozier" apparatus of the Ascomycetes (Fig. 11 D). A septum then forms which divides the "crozier" into two cells, a basal cell and a terminal cell which are, as far as position goes, actually side by side (Fig. 11 E). The terminal cell then enlarges downward so that it appears pendent, while the basal cell enlarges upward and away from the terminal cell and becomes somewhat triangular in shape (Fig. 11 F). Four new growing points now appear almost simultaneously, one at each end of the pendent terminal cell, one at the uppermost and outermost point of the basal cell and the fourth on the basal-cell side of the septum that originally divided the spore primordium in half (Fig. 11 G–H).

The method of growth of these growing points is quite different from that which pertains in all the other aquatic Hyphomycetes investigated. Instead of growing out in a straight, perpendicular line, each of the growing points produces an appendage that is bent into a tight arc and almost the entire elongation of the appendages takes place in this position (Fig. 11 I–J). About two or two and one half hours before the spore is shed the appendages begin to straighten out (Fig. 11 K). When the straightening process is completed, the spore, an aleuriospore, is set free by the disarticulation of the basal septum (Fig. 11 L).

The aleuriospore is a multicellular structure. Each of the appendages, which superficially resemble the appendages on the cleistothecium of *Phyllactinia*, is set off from the main body of the spore by a transverse septum. The pedent portion that bears an appendage at each end is divided by one or more transverse septa exclusive of those which delimited the appendages; the pendent portion is actually a branch of the spore attached more or less transversely to the main body of the spore by a narrow isthmus. The large triangular basal cell is sometimes divided by one or more cross-walls so that one of the appendages arising from this "cell" appears to be at the end of a short branch (Fig. 11 L). The mature aleuriospore of this fungus, then, is an asymmetrical, multicellular branched structure with four unicellular divergent appendages. When the spore is shed, a second one is formed at the end of the sporophore following a slight elongation of the terminal portion of the sporophore slightly to one side of the site of the first spore (Fig. 11 M). Aleuriospores are produced in succession but not basipetally.

A number of single-spore, pure cultures were obtained from the material collected in Sonoma County. On malt agar an isabelline mycelium was produced with a large amount of fluffy greyish aerial mycelium. Occasionally rather closely compacted knots of hyphae were formed about 0.5 mm. in diameter in the aerial mycelium. Spores were not formed on agar. Even when slices of the agar colony were placed in water only a few spores were formed but similar in appearance to those found in nature. When these spores were planted on agar no germination occurred. Attempts to germinate these spores in hanging-drops also failed. It was found that after being in culture for about three weeks those few cultures that did produce spores no longer did so.

If text-figure 1, #18 of Ingold's paper on the aquatic Hyphomycetes (1942) is examined, it will be noticed that there is a striking similarity between this figure and the fungus just described and figured. Ingold listed that spore as one of unknown

identity. While no claim is being made that these two are identical, it seems, on the basis of the structure of the spore Ingold figured, that it may very well fit into the same genus as the fungus here described. Ingold's figure shows an asymmetrical, multicellular spore with four divergent appendages and seems to have the main body of the spore branched as well. Until developmental studies can be made on that organism, the issue will, of course, be in doubt.

Since our fungus resembles no known described organism, it is proposed that it be made the type of a new genus, *Campylospora*. The name is suggested by the bent or "crozier-like" form of the spore primordium and the fact that the appendages of the spore are also bent into an arc during the course of their development.

Campylospora n. gen.

Submerged aquatic fungi with branched, septate, mycelium. Aleuriospores septate, colorless, asymmetric, consisting of a basal cell with two divergent appendages and a lateral branch with two divergent appendages.

Campylospora chaetocladia n. sp.

Submerged aquatic fungus with branched, septate, colorless mycelium. Aleuriophores colorless, unbranched, 10–20 mu long, 2–2.5 mu broad. Aleuriospores colorless, terminal, multicellular, each consisting of a basal cell 8.5–12 mu wide, 10–14 mu long, with two divergent appendages of approximately the same length, 35–50 mu long, 6–3 mu wide at the point of attachment to the basal cell and tapering to about 1.5 mu at the tips; and a lateral branch, 10–25 mu long attached perpendicularly to the transverse axis of the aleuriospore and bearing at each end an appendage similar in appearance to those on the basal cell. Aleuriospores produced in succession but not basipetally.

Hab. On decaying submerged leaves of *Acer* sp. in a stream in Sonoma County, California.

Campylospora gen. nov.

Fungi submersi aquatici a mycelio ramoso, septato, sine colore. Aleuriosporae setatae, sine colore, asymmetricae, a cellulo basale cum duo radiis divergentibus et ramulo laterale cum duo radiis divergentibus, composita.

Campylospora chaetocladia sp. nov.

Fungus aquaticus submersus a mycelio ramoso, septato, sine colore. Aleuriophorae sine colore, breves, simplices, 10–20 mu longitudine, 2–2.5 mu latitudine. Aleuriosporae sine colore, multicellulares, compositae a cellulo basale 8.5–12 mu latitudine, 10–14 mu longitudine, cum duo radiis subaequalis divergentibus in diversis angulis, 35–50 mu longitudine, 6–3 mu latitudine ad punctum a cellula basale affixum ad cacuminem ad 1.5 mu attenuata, et ramulo laterale, 10–25 mu longitudine in perpendiculum ad axem transversalem aleuriosporae affixus, ad apices alteruter radio ad eos cellulae basalae simile, ferens. Sporae deinceps evolutae, evolutio a elongatine paullo sporophorae subsecuta essens.

Hab. In foliis submersis putrescentibusque *Acer* sp. in rivulo, Comitate Sonoma, California.

FLAGELLOSPORA CURVULA Ing.

Flagellospora curvula (Fig. 1 D, 12 A–F), the type of the genus, was collected and described by Ingold in 1942. Though common enough in England, it was collected only twice in California; both collections were made during April of 1949. It may be much more common than it appears to be. It was cultured more by accident than by design since the spores that were isolated were thought to be those of *Anguillospora longissima*.

In spite of the gross similarity that exists between the spores of *A. longissima* and *F. curvula*, the fungi are quite different in at least one important respect and several minor ones. On malt agar *F. curvula* makes a dense light-brown colony with a few wisps of aerial mycelium in the form of erect cords near the point of inoculation. Conidia are produced only when a slice of the colony is placed in water. It is assumed that these spores are similar to those formed in nature; they are in complete agreement with Ingold's drawings and photographs. The sporophores are relatively simple and possess a short unbranched basal portion, 50–75 mu in length and 2.5–3 mu in diameter, which bears at the tip a number of short branches. The branches either bear phialides or are themselves phialides. The phialides are somewhat clavate, 18–25 mu in length and about 3–4 mu in diameter near the apex and taper to 2–2.5 mu at the base. From the tips of the phialides are produced in succession sigmoid or crescent shaped non-septate conidia, 100–150 mu in length and 2–2.5 mu broad at the widest point and taper gradually to 1–1.5 mu at the ends. These conidia germinate well in water as Ingold has pointed out. It is, however, only a relatively small precentage that will grow well when planted on malt or prune agar.

Since *F. curvula* produces true conidia in the form of phialospores it is clear that Ingold was justified in excluding it from the genus *Anguillospora* on the grounds that the latter is founded on a fungus characterized by aleuriospores.

Flagellospora curvula Ing., *Trans. Brit. Myc. Soc.*, Vol. XXV, 402:1942.

Submerged aquatic fungus with septate, branched, colorless mycelium. Conidiophores colorless, branched, bearing a number of phialides. Phialides clavate, 18–25 mu long, 3–4 mu broad near the apex, tapering downward to 2–2.5 mu at the base. Conidia colorless, sigmoid or lunate, non-septate, 100–150 mu in length, 2–2.5 mu broad in the middle and tapering to 1–1.5 mu at the tips; produced in basipetal succession on the phialides.

FLAGELLOSPORA PENICILLIOIDES Ing.

The second species in the genus *Flagellospora* (Figs. 1 E, 12 G–K) was collected and described by Ingold (1944) in England. It has been found several times in California during the spring, summer and fall months of the year. It has been found principally on decaying and submerged willow leaves and on the leaves, twigs and samaras of maple.

The conidiophores are perhaps the most conspicuous feature of this species. They are well developed, much branched as a rule and are strikingly similar in structure to those found in the genus *Penicillium*. They frequently attain a length of 200 mu or more. The branches of the conidiophore terminate in clusters of six to eight bottle-shaped phialides. The phialides are 15–20 mu in length and 2.5–3 mu broad at the widest point and taper slightly both upward to about 1 mu and downward to about 1.5–2 mu at the base. From the tips of the phialides conidia are produced in basipetal succession.

The conidium begins its development as a finger-like process from the tip of the phialide (Fig. 12 G–I). Subsequent development consists primarily of increase in diameter and in length. Growth in length is not all in one plane so that the mature conidium is more or less sigmoid or lunate in shape. When the conidium is mature, a cross-wall is quickly formed at the base and the conidium is quickly shed. Ordinarily the conidia are one-celled when shed; shortly after release, but before germination, they become more or less equally two-celled.

The conidia germinated readily in water or on malt or prune agars. On malt agar, colonies from single-spore isolations formed a dense mycelial mat with some scanty aerial growth, much of which was aggregated into mycelial cords. When these were examined microscopically it was found that the cells of these strands had somewhat thicker walls and more oleaginous contents than the other hyphae. The colony was at first white, but soon became a deep reddish-brown and the agar itself soon took on this color. Only when slices of the colony were placed in water were conidiophores

and conidia produced in any numbers. Occasionally conidiophores and conidia would be produced from the cut surfaces in petri dish culture. Spore formation occurred in about twelve hours after the mycelium was placed in water; the conidia and conidiophores were similar to those found in nature and arose for the most part from the mycelial cords. The sclerotia, observed by Ingold, were not seen.

In spite of Ingold's doubts in the matter, the genus *Flagellospora* seems to be a perfectly satisfactory choice for this fungus. The conidia of *F. curvula* and *F. penicillioides* are very much alike, i.e., unicellular when shed, sigmoid or lunate, and borne on phialides. The principal difference between the conidia is one of size. The difference in conidiophore structure, which to Ingold was the chief point of doubt, is a difference in degree rather than in kind. Merely shorten the unbranched basal portion of the conidiophore of *F. penicillioides* from 200 mu to something like 25–50 mu and the conidiophore of *F. curvula* is very closely approximated. On the whole, the genus *Flagellospora* seems to be a very good place for this fungus.

Flagellospora penicillioides Ing., *Trans. Brit. Myc. Soc.*, Vol. XXVII, 41:1944.

Submerged aquatic fungus with septate, branched, colorless mycelium. Conidiophores colorless, penicillioid, main axis 100–200 mu long, 3.5–5 mu broad, bearing branches of several orders and each terminating in a cluster of 6–8 ampulliform phialides, 15–20 mu long, 2.5–3 mu broad. Conidia sigmoid or lunate, colorless, 35–45 mu long, 2.5–3 mu wide in the middle and tapering to 1.5–2 mu at the ends; produced in basipetal succession from the phialides. Conidia when shed become two-celled.

HELISCUS AQUATICUS Ing.

When Ingold first described this species (Figs. 1 J, 13 A–I) in 1942 he referred to it as one of the rarer aquatic Hyphomycetes. This is also the case with *Heliscus aquaticus* in California; it was collected only once in October of 1947 on a submerged and decaying leaf of *Cornus* sp.

The colorless conidiophores, which may be simple or sparingly branched, terminate in phialides; the simple conidiophores bear only one phialide. A small spherical swelling at the tip of a phialide is the first indication of the spore primordium (Fig. 13 D). This soon becomes either roughly cylindrical or clavate. The cylindrical primordia remain more or less the same diameter throughout, about 4 mu, whereas the clavate primordia, 20–30 mu in length and 2–2.5 mu broad at the base, expand upwardly so that the apex may measure 5–6 mu. Frequently from the apex of the spore primordium three short, divergent and abruptly tapering processes or branches, 2–8 mu in length, arise simultaneously. Our fungus seems to be even more polymorphic than the organism described and figured by Ingold; many of the spores are without any protuberances at all. As soon as the spore is mature, a cleavage line forms between the spore and the phialide and the conidium is shed. A new spore primordium begins its development immediately after the first conidium is shed (Fig. 13 F–G). Ordinarily when the conidia are shed they are unicellular, but shortly before germination, a transverse septum appears roughly midway along the length of the conidium; two or even three such septa are frequently formed. The conidia germinate very quickly after release.

In addition to the large submerged conidia, it was observed that occasionally a phialide would produce a small oval "microconidium," 2–6 mu long and 1.5–3 mu wide, between successive macroconidia (Fig. 13 G–I); this was especially true in culture. The "microconidia" were of great variability, not only as to size but also in the ability to germinate. The larger ones with more or less homogeneous contents germinate as quickly as the macroconidia. The smaller ones, 2×1.5 mu, had a small refractile globule at each end of the spore and were not observed to germinate. How much of this behavior is a result of nutrition and other conditions is impossible to state at this time.

A number of pure, single-spore cultures were obtained from the original collection.

On malt agar this fungus produced a light brown mycelial mat with a fluffy cream colored aerial growth. In contrast with Ingold's collections, our fungus grew rather poorly on malt agar. When a slice of the colony was placed in water conidia were produced in great numbers. These conidia differed from those observed in nature merely in the higher proportion of conidia without protuberances.

When the cultures aged, conidia were produced aerially in two ways. In certain cases conidiophores or even just phialides arose on the aerial hyphae and formed conidia. On much older cultures, six to eight weeks, sclerotial bodies were formed in the agar. The sclerotia were composed of thick-walled, densely pigmented and tightly packed globose cells. From the sclerotia conidiophores arose in sufficient numbers to form a rather loosely organized sporodochium. It is interesting to note that almost without exception the aerial conidia were without protuberances; at most they displayed only some small irregularity of form at the terminal ends (Fig. 13 A). It is also interesting to note that a large number of the aerial conidia were composed of many more than two cells each.

Chlamydospores were frequently found in the older cultures. In general they were spherical, 10 mu in diameter, and terminal on relatively short hyphal stalks. Occasionally they were intercalary or in short chains. The wall was smooth and yellow-brown in color and relatively thick. The contents were conspicuously oleaginous in character (Fig. 13 B). So far attempts to germinate these chlamydospores have failed. It is likely, however, that these spores serve as a hold-over mechanism during dry periods.

As Ingold (1942) has pointed out, *Heliscus aquaticus* resembles very closely *H. lugdunensis* Sacc. & Therry (Saccardo, 1880) which was found growing on pine bark. This similarity is expressed both in the general shape of the conidia, i.e., clove-shaped, and in the formation of sporodochia, though for *H. aquaticus* the sporodochium-formation seems to be a function of the cultural conditions and has not been observed in nature. It is also probable, from the published figures, that the conidia of *H. lugdunensis*, though no developmental details were given, are produced on phialides. In the light of the aquatic habitat and the high proportion of two-celled spores produced in nature and in the short instead of the elongated terminal protuberances, it seems reasonable to maintain *H. aquaticus* as a species distinct from *H. lugdunensis*. The recent paper by M. and Mme. Fernand Moreau (1949) seems to support this idea though these investigators were convinced that they were dealing with *H. lugdunensis*. It is quite clear from their figures and descriptions that their fungus and the California specimen are the same. It is also more than likely that the polymorphism of the spores, observed by Ingold, Moreau and myself, is largely a function of cultural conditions.

Heliscus aquaticus Ing., *Trans. Brit. Myc. Soc.*, Vol. XXV, 367:1942.

Submerged aquatic fungus with branched, septate, colorless mycelium. Conidiophores colorless, short, simple to sparingly branched, 50 mu long, 2.5–3 mu broad, bearing one or more phialides 25–40 mu long, 3.5 mu wide at the base and tapering gradually upwards to 1–1.5 mu. Submerged macroconidia, colorless, cylindrical or clavate, 20–30 mu long, 5–6 mu broad at the apex, two celled, usually bearing at the apex a corona composed of three short, abruptly tapering, divergent protuberances, 2–8 mu long. Submerged microconidia, colorless, oval, 2–6 mu long, 1.5–3 mu wide, produced on the same conidiophores with and alternating with the macroconidia. Aerial conidia colorless, macro- and microconidia; macroconidia cylindrical, or clavate, 30–40 mu long, 5–6 mu broad, usually without terminal corona. Conidia produced in basipetal succession.

ALATOSPORA ACUMINATA Ing.

Ingold collected and described this species (Figs. 1 C, 13 J–P) as the type of a new genus. Though common in England during the winter and spring months, it was only found during the spring and summer months in California. It was never

found in great quantity and then only on skeletonized leaves. Since the conidia are relatively delicate in structure, it is quite possible that the organism was overlooked more often than not.

The short conidiophores, 10–20 mu in length and 2.5 mu in diameter, are generally simple but may be sparingly branched and bear one to several bottle-shaped phialides similar to those of *Flagellospora penicillioides*. A narrow, filiform extension from the apex of the phialide becomes the spore primordium (Fig. 13 J–K). When the spore primordium attains a length of some 20–30 mu it becomes somewhat clavate and begins to exhibit a slight curvature. As apical growth continues, this curvature becomes more and more marked so that eventually a wide angle bend, some 220 degrees, is formed (Fig. 13 L–N). At a stage when the curvature is well marked and a short distance back from the growing tip, two new growing points arise side by side on the convex side of the axis (Fig. 13 J). The growing points develop into two lateral, divergent branches, 18–25 mu in length and taper to very fine points (Fig. 13 O–P). When the unicellular conidium is mature, a transverse wall quickly forms between the conidium and the phialide and the conidium is released. As soon as the conidium is shed a new one begins to form at the apex of the phialide (Fig. 13 L–N).

While the form and development of the conidium of *Alatospora acuminata* is like that of the spore of *Tetrachaetum elegans*, these two species should be ranked in different genera since the spore of the first is a phialospore (conidium) and the spore of the second is an aleuriospore.

The species has been isolated several times in pure, single-spore culture. On malt agar the fungus formed a dense, tough brownish colony of septate, branched hyphae with no aerial mycelium. No conidia were formed on agar and when a slice of the colony was placed in water conidium production was very scanty and frequently lacking. After the cultures were more than a few weeks old, spores failed to form at all, even if they had once done so. Such conidia as were formed in culture, however, were identical to those found in nature.

Alatospora acuminata Ing., *Trans. Brit. Myc. Soc.*, Vol. XXV, 381:1942.

Submerged aquatic fungus with branched, septate, colorless mycelium. Conidiophores colorless, 10–20 mu long, 2.5 mu broad, simple or sparingly branched, terminated by one or several ampulliform phialides, 15 mu long, 2.5 mu broad. Conidia unicellular, colorless, each consisting of a main axis, 38–45 mu long, bent in the middle, tapering from 2.5 mu in the middle to a fine point at each end, and two divergent, tapering branches 10–25 mu long arising at the same level on the convex side of the main axis. Conidia produced in basipetal succession on the phialides.

LEMONNIERA AQUATICA De Wild.

In the same collections of algae made in the Botanical Garden at Nancy in which De Wildeman (1894) discovered *Tetracladium marchalianum* was also found this beautiful fungus, the type species of the genus. Ingold (1942) also found it and included it in his papers on the aquatic Hyphomycetes. It is extremely common in California; it was found throughout the year on a wide variety of submerged and decaying angiosperm debris. The morphology and developmental sequences of conidiophore and conidium agree exactly with the descriptions and figures of De Wildeman and Ingold.

Lemonniera aquatica (Fig. 1 O) was isolated many times in pure, single-spore culture. It grows slowly on malt agar but the majority of isolates exhibited the cultural characteristics described by Ingold. There are, however, two other cultural types. In the first, which otherwise agrees with Ingold's cultures, there is also a deep reddish-brown pigment, diffused out into the agar, as well as a sprinkling of brownish-black sclerotia, both on the surface and submerged in the agar. When a

slice of this colony is placed in water conidiophores and conidia are produced scattered over the surface of the colony and from the sclerotia. In the second type of divergent colony there is little if any brownish pigment, either in the mycelium or diffused out into the agar. There is, however, a copious production of hard, irregular, black sclerotia over the surface of the agar. The sclerotia, often confluent, are roughly arranged in concentric rings about the point of inoculation. When slices of this type of colony are placed in water, conidiophore- and conidium-production is almost entirely limited to the sclerotia. Generally in all three types, when single spore inoculations are made, the parental type of colony is maintained. In some, however, there occurs a spontaneous sectoring out of any one or both of the other two types which indicates a heterocaryotic condition.

Lemonniera aquatica De Wild., *Ann. Soc. Belge Microsc.*, Vol. XVIII, 143:1894.

Submerged aquatic fungus with branched, septate, colorless mycelium. Conidiophores penicillioid, colorless, branched, 100–400 mu long, 4–6 mu broad, bearing at the tips of the branches a number of ampulliform phialides, 20–30 mu long, 5–7 mu broad at the widest point. Conidia colorless, each consisting of 4 more or less equal divergent branches, 50–120 mu long; one of the branches is in parallel continuation of the longitudinal axis of the phialide; conidia attached at the point of union of the four branches to the phialides. Conidia produced in basipetal succession.

LEMONNIERA CORNUTA n. sp.

A second and distinct species of this genus (Figs. 1 S, 14 A–J) was found throughout the year on a wide variety of submerged and decaying angiosperm material. It is one of the more common aquatic Hyphomycetes, especially in the late summer and fall months, in California. It is frequently found growing with *L. aquatica*.

The conidiophores are very well developed, varying in length from 50 to 600 mu or more and 5–6 mu broad, and are similar in structure to the Asymmetrica-Divaricata grouping in the Penicillia. Each branch of the conidiophore terminates in a number of bottle-shaped phialides similar in structure to those of *L. aquatica*.

A small spherical swelling at the tip of a phialide is the first indication of conidium-formation (Fig. 14 B). The spherical swelling soon becomes quite flattened at the apex to form an inverted tetrahedron. The tetrahedron quickly resolves itself into four growing points that develop simultaneously and are situated almost at right angles to each other and transverse to the longitudinal axis of the phialide (Fig. 14 C–D). For a very short time the growing points grow in a straight line and in the same plane. Then one oppositely directed pair of growing points begin to grow in an upward direction and the other pair, 90° away, begin to grow downward (Fig. 14 E–H). When the conidium is fully grown, a transverse septum quickly forms between the phialide and the conidium and the release of the spore occurs. As soon as the conidium is shed another one begins its development from the apex of the phialide (Fig. 14 A–B). Ordinarily the branches of the conidium are non-septate when it is shed; soon afterwards one or more septations appear in each branch. The mature discharged conidium is a multicellular, tetraradiate structure in plan with each opposite pair of branches curved in opposite directions like two crescent moons back to back and at right angles to each other.

L. cornuta has been isolated in pure, single-spore culture several times. In general the colonies on malt agar resemble the majority of colonies of *L. aquatica*, i.e., a brown mycelial mat with isabelline aerial mycelium and myceliae cords composed of hyphae with inflated cells. Some of the colonies, on the other hand, developed roughly concentric rings of dark brown sclerotia that were similar in behavior to those found in *L. aquatica*. In culture conidia were obtained only when a slice of the colony was placed in water; in twenty-four hours large numbers of conidia were produced, not only from the ordinary conidiophores on the hyphae but from the sclerotia if

present. The conidia and conidiophores were similar in all respects to those found in nature.

Lemonniera cornuta n. sp.

Submerged aquatic fungus with branched, septate, colorless mycelium. Conidiophores colorless, penicillioid, consisting of an unbranched basal portion, 50–600 mu long, 5–6 mu broad, terminating in a number of branches each bearing a number of ampulliform phialides, 20–30 mu long, 5–7 mu broad at the widest part. Conidia consisting of 4 divergent branches, usually septate, approximately equal in length, 30–45 mu long, 3–5 mu wide at the base and tapering to 2.5 mu at the tips; each pair of branches curved in opposite directions; inserted on the phialide at the point of divergence of the branches, the branches at right angles to the longitudinal axis of the phialide. Conidia produced in basipetal succession.

Hab. On submerged and decaying leaves and twigs of *Salix* sp. and *Quercus Kellogii* in Putah Creek, Napa County, California.

Lemonniera cornuta sp. nov.

Fungus aquaticus submersus, a mycelio septato, ramoso, sinecolore. Conidiophorae sine colore, habitii Penicillii, stirpe simplice, 50–600 mu longitudine, 5–6 mu latitudine, deliquescente in plurisibus ramulis, omnibus ferentibus phialides ampullaceous 20–30 mu longitudine, 5–7 mu latitudine maxima. Conidia dienceps e phialidibus evoluta. Conidia sine colore, radiis divergentibus, fere septatis, subaequallis, 30–40 mu longitudine, 3–6 mu latitudine basin, ad cacuminem ad 2.5 mu attenuatis; hoc par radiorum perpendiculare divergente, inflectum, ab altera pare; in phialidum ad punctum divergentiae radiorum affixis, radiis ad perpendiculum ad axem longitudinalum phialidis.

Hab. In foliis et ramulis submersis putrescentibusque *Salicis* sp. et *Querci Kellogii* in rivulo Putah, Comitate Napa, California.

DISCUSSION

The fungi studied were limited to the moniliaceous, fresh-water forms, i.e., whatever the pigmentation of the mycelium, the spores and sporophores were colorless. No attempts were made to study any of the observed dematiaceous forms nor those Hyphomycetes in marine or brackish-water habitats. With one exception, *Dactylella aquatica*, all collections were made within the boundaries of the state of California.

California contains areas of great climatic diversity. These range from the Colorado-Mohave deserts with an annual rainfall of five inches or less to the Redwood Coastal Belt in the northwestern part of the state with an annual rainfall of 25 to 122 inches and to the timberline and true alpine areas with a mean temperature of 40° to 50° F. and an average rainfall of 50 to 70 inches. The bodies of fresh-water in the state are also highly variable. Rivers vary all the way from the navigable to the highly temporary ones in which the chief characteristics are a boiling yellow flood following a brief period of rain and a thin trickle or no water at all during the rest of the time. The same situation pertains to streams and creeks. Lakes are less variable but some are dry for prolonged periods. Many lakes, streams and ponds, especially in the southern por-

tions of the state are quite alkaline and warm. Collections were made from as many geographical and climatic regions as possible with the following counties covered (Fig. 15):

Napa	San Bernardino	Monterey	Klamath (Oregon)
Alameda	Inyo	Tehama	Shasta
Contra Costa	Mono	Siskyou	Tulare
Marin	San Diego	San Mateo	Los Angeles
Solano	Santa Barbara	Modoc	Humbolt
Madera	Mendocino	Sonoma	Placer
San Joaquin	Fresno	Del Norte	Calaveras
	Glenn	Tuolumne	

With the exceptions of the collections made from creeks and ponds in the Mohave Desert (San Bernardino Co.), Death Valley (Inyo Co.), Shoshone (Inyo Co.) and Lone Pine (Inyo Co.) in which the alkalinity was too high, all collections revealed the presence of these fungi. It was also found that the same species occurring in the relatively warm streams of San Diego and Los Angeles Counties were also present in the melting snow freshets of Mount Lassen and in temporary and permanent streams, lakes and ponds everywhere. Far from being restricted either to North Temperate Europe or to Northeastern United States, they may very well be world wide in their distribution.

One of the most remarkable features of the aquatic Hyphomycetes is the bizarre and often spectacular shape of the spores. The majority of these fungi are characterized by branched spores, whereas only a few genera, *Margaretispora*, *Flagellospora*, *Anguillospora*, *Lunulospora* and *Dactylella*, are characterized by unbranched spores. Of this group, three of them, *Flagellospora*, *Anguillospora*, and *Lunulospora* are characterized by the production of elongate, sigmoid spores.

With such a high proportion of branched and elongate sigmoid spores represented in this group, it would seem that there is an advantage in possessing one or the other of these shapes. While it is easy to read more into a structure than is actually there, two feasible explanations present themselves without straining credibility too much: a, the coming to rest on a suitable substratum and b, the dispersal of the organism.

It is quite probable that the branched or sigmoid form is of great advantage in the anchoring of the spore to a suitable substratum, especially if the substratum is a decomposing or skeletonized leaf. The spore would submit readily to entanglement with the shreds of veinlets or with the remnants of the parenchyma still clinging to the veins. Ingold has extended this advantage downward to the sporophores themselves, i.e., the sporophores elevate the spores sufficiently to allow them to be carried away by the water currents without being trapped at the source. This is a very reasonable supposition and is probably quite true for the majority. However, if so, it would seem that this "purpose" is defeated in *Alatospora acuminata*, *Campylospora chaetocladia* and *Articulospora moniliform* with their very short sporophores.

The entanglement process seems to be materially aided by another factor exhibited by many of the species. This is the formation of appressoria very soon after the spore has come to rest; this factor is strikingly apparent in *Anguillospora longissima* and *Clavariopsis aquatica*, for in water cultures of these two species the spores form appressoria almost as soon as they have come in contact with the bottom of the culture dish and within a few minutes are firmly attached to the bottom of the dish.

In considering the advantage of the branched and sigmoid spores with respect to the ease with which they may be trapped on the substratum, it must be borne in mind that this advantage may be more apparent than real. The unbranched spores of *Dactylella aquatica* and the unbranched spore forms of *Heliscus aquaticus*, for example, germinate within a very few hours, as do all the spores in this group. The germ-tubes produced are quite capable of performing the same functions attributed to the branches of the branched spores, an observation that is borne out by the examination of any water culture of these fungi.

When one considers the problem of dispersal, one is reminded of the situation that exists in the saltwater Peridinaceae. Here there is a correlation between the length of the appendages and the density of the water. The warmer the water, and therefore less dense, the longer are the appendages of these peridinaceous organisms and the colder the water the shorter are the appendages. This is apparently a mechanism to maintain a resistance balance with the water that acts as an aid in floating. Thus one of the more important features of the branched and sigmoid form of the aquatic Hyphomycetes is the resistance that these shapes offers to the movement of water. As observed in water cultures, these spores float very efficiently and are doubtless carried long distances by the movement of water in the natural habitat.

Many of the California water courses are dry for the greater part of the year. During the early spring months, however, collections of suitable material from these temporary streams and ponds revealed the presence of many aquatic Hyphomycete species. There is, then, some sort of efficient "holding-over" mechanism. With sclerotia in several species and chlamydospores in at least one, this is not so surprising. When skeletonized leaves were collected, either from stream beds or ponds several months after the water had evaporated or from debris left behind by the floods, and placed in water, it was found that sporophores and spores were formed in large numbers in about forty-eight hours. The interesting fact was that it was *Anguillospora longissima* and not the sclerotial forming species that was the dominant and frequently the only species present. What the "holding-over" mechanisms are here is not yet known. It is assumed for want of other evidence that it is the thicker-walled, more densely pigmented hyphae, such as are formed in culture, that act to hold the organism over until favorable conditions return.

ACKNOWLEDGMENTS

I wish to express my deep appreciation to Professor Lee Bonar for his enthusiastic and continued interest and his help throughout the course of this work. I also would like to thank Professor Ralph Emerson for his assistance and advice which he gave willingly during the study. For his assistance with the latin diagnoses, I wish to thank Mr. David S. Erskine.

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Fig. 1. The aquatic Hyphomycetes found in California are represented as growing on a single, hypothetical substratum. The substratum is represented by the irregular line at the bottom.
A. *Anguillospora longissima* (Sacc. & Syd.) Ing. **B.** *Tricladium angulatum* Ing. **C.** *Alatospora acuminata* Ing. **D.** *Flagellospora curvula* Ing. **E.** *Flagellospora penicillioides* Ing. **F.** *Tetracladium marchalianum* De Wild. **G.** *Tetracladium setigerum* (Grove) Ing. **H.** *Tetracladium monosporus* Ing. **I.** *Tetrachaetum elegans* Ing. **J.** *Heliscus aquaticus* Ing. **K.** *Anguillospora gigantea* n. sp. **L.** *Dactylella aquatica* (Ing.) n. comb. **M.** *Tricladium gracile* Ing. **N.** *Articulospora moniliforma* n. sp. **O.** *Lemonniera aquatica* De Wild. **P.** *Articulospora tetracladia* Ing. **Q.** *Campylospora chaetocladia* n. sp. **R.** *Clavariopsis aquatica* De Wild. **S.** *Lemonniera cornuta* n. sp. **T.** *Anguillosporo pseudolongissima* n. sp. **U.** *Tricladium splendens* Ing. **V.** *Lunulospora curvula* Ing. × 400.

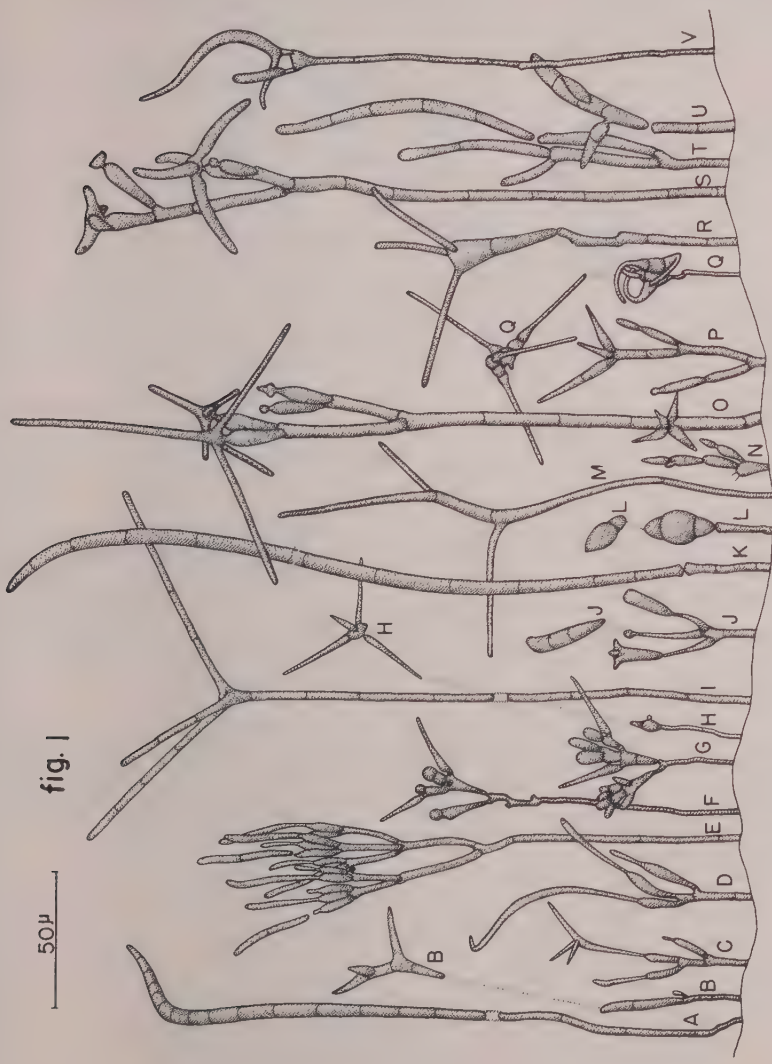
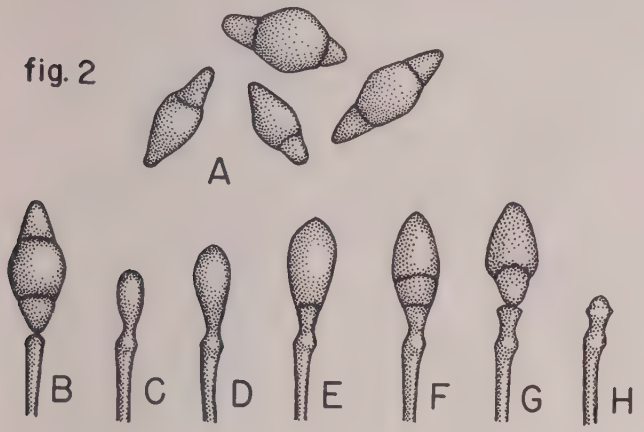


fig. 1

Fig. 2. A–H. *Dactylella aquatica* (Ing.) n. comb.
A. Mature aleuriospores. **B–H.** Stages in the development of an aleuriospore. **B.** Mature aleuriospore at the time of release. **C.** The spore primordium at 11:50 A.M. **D.** 1:15 P.M. **E.** 2:25 P.M. **F.** 3:15 P.M. **G.** The release of the mature aleuriospore at 4:10 P.M. **H.** The sporophore beginning to elongate prior to the formation of a new spore. From a hanging-drop culture of the fungus growing on a decayed leaf. × 700.

Fig. 3. A. *Anguillospora pseudolongissima* n. sp., showing the phialides and phialospores. **B–G.** Stages in the development of the aleuriospore of *Anguillospora gigantea* n. sp. **B.** An early stage in the development of the spore primordium. **C.** The spore primordium at 10:15 A.M. **G.** The mature aleuriospore at the time of release, 5:38 P.M. From hanging-drop, pure cultures. × 700.

fig. 2



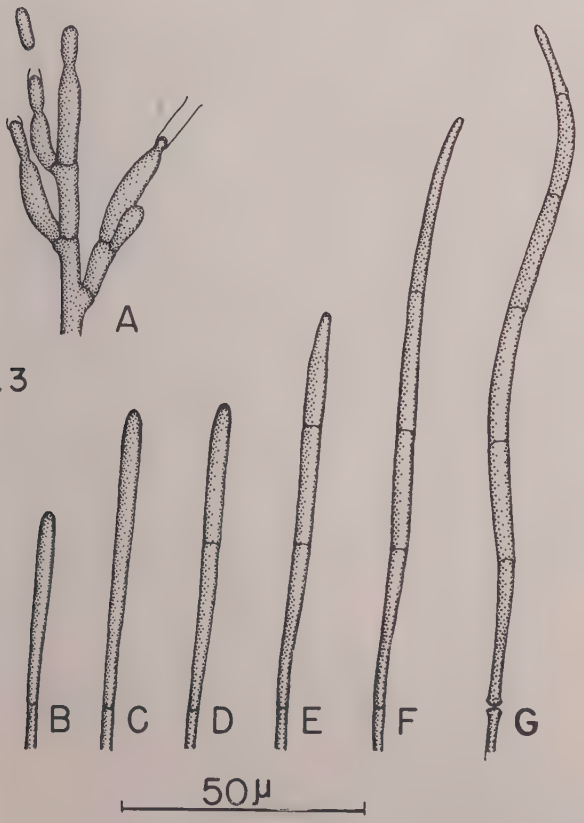


fig. 3

Fig. 4. A I. *Lunulospora curvula* Ing., showing the development of the aleuriospores. **A.** A tip of a sporophore showing a half-matured aleuriospore and a young spore primordium at 10:15 A.M. **B.** The same spores at 11:00 A.M. **C.** 11:45 A.M., note the formation of the cross-wall that delimits the spore primordium. **D.** 12:25 P.M. **E.** The mature spore has been shed and the spore primordium shows a pronounced curvature at 1:10 P.M. **F.** 1:45 P.M. **G.** The initiation of a new spore primordium is well under way at the left of the expanded sporophore tip, 2:35 P.M. **H.** 3:30 P.M. **I.** The mature spore and the new spore primordium at 4:00 P.M. By 5:00 the mature spore had been shed and a new spore primordium initiated near that same spot. From hanging-drop, pure culture. × 560.

Fig. 5. A G. *Articulospora tetracladia* Ing. showing the development of the aleuriospores. **A.** The spore primordium had appeared as a small spherical swelling at the tip of the lower left branch of the sporophore by 9:15 A.M. **B.** The cross-wall has formed at the base of the spore primordium, and the small swelling at the apex of the spore primordium is the beginning of the second branch of the spore, 11:35 A.M. **C.** The other spore, in this case a three-branched one, is in the process of being shed, 12:10 P.M. **D.** The third branch of the spore is just appearing, 2:10 P.M. **E.** By 3:45 P.M. the fourth branch of the spore has appeared. **F.** 5:00 P.M. **G.** The mature aleuriospore at the time of release, 6:10 P.M. From a hanging-drop, pure culture. × 560.

fig. 4

fig. 5

Fig. 6. A–G. *Tricelophorus monosporus* Ing., showing the development of an aleuriospore. **A.** The spore primordium has been delimited from the sporophore by a cross-wall, 12:30 P.M. **B.** The formation of the basal cell and the terminal cell; the latter will form one of the four divergent branches of the spore, 1:25 P.M. **C.** The initiation of the second branch, 1:50 P.M. **D.** 2:25 P.M. **E.** 4:00 P.M. **F.** The same spore at 6:30 P.M. **G.** The release of the mature aleuriospore took place at 6:50 P.M. From a hanging-drop, pure culture. × 560.

Fig. 7. A–G. *Tricladium splendens* Ing. **A.** The spore primordium with the delimiting septum at the base, 10:30 A.M. **B.** The spore primordium with its first transverse septum, 11:40 A.M. **C.** The first branch of the spore is visible as a "bud" 1:25 P.M. **D.** The spore primordium has elongated somewhat and a second transverse septum has appeared by 2:25 P.M. **E.** The second of the two divergent branches is visible 3:30 P.M. **F.** The same spore showing curvature of the axis at 5:30 P.M. **G.** Release of the aleuriospore at 6:35 P.M. From hanging-drop, pure culture. × 560.

Fig. 7. H–N. *Tricladium angulatum* Ing. **H.** The spore primordium with the delimiting septum at the base, 8:50 A.M. **I.** The first transverse septum, 10:00 A.M. **J.** The same spore showing the initiation of the first of two divergent branches and curvature of the axis, 11:05 A.M. **K.** 12:15 P.M. **L.** The second divergent branch has appeared, 1:15 P.M. **M.** The spore at 2:10 P.M. **N.** The mature aleuriospore at the time of release, 3:35 P.M. From hanging-drop, pure culture. × 560.

Fig. 8. A–E. *Tricladium gracile* Ing. **A.** The spore primordium already exhibited the curvature of the main axis and was delimited from the sporophore, 11:35 A.M. **B.** The initiation of the first branch is shown below the first transverse septum, 1:15 P.M. **C.** The second branch, 2:00 P.M. **D.** The mature aleuriospore at the time of release, 4:25 P.M. **E.** The phialides and phialospores of this species. From a hanging-drop, pure culture. × 500.

Fig. 9. A–G. *Articulospora moniliforma* n. sp., showing the development of the aleuriospores. **A.** A short section of the sporophore with one almost mature spore and to the right a spore primordium with the first branch fully developed and the second branch showing as a spherical swelling at the apex, 9:20 A.M. **B.** A bud has developed that will form a branch of the sporophore, 10:10 A.M. **C.** A two-branched spore has been discharged and the spore primoridum to the right of it has produced the third branch, 11:05 A.M. **D.** 12:00 noon. **E.** 1:10 P.M. **F.** 2:00 P.M. **G.** The mature spore has been released, 2:30 P.M. From a hanging-drop, pure culture. × 500.

fig. 6

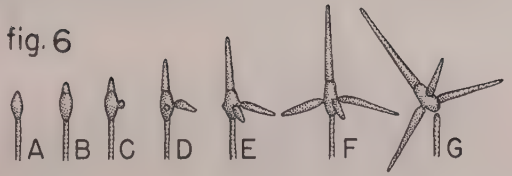
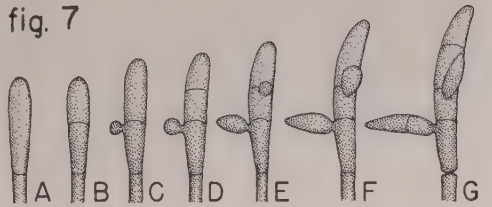


fig. 7



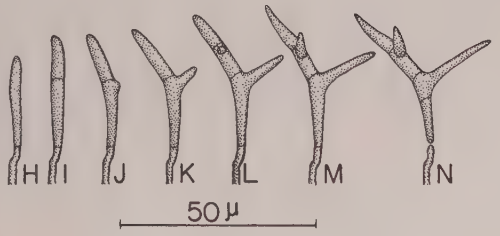


fig. 8

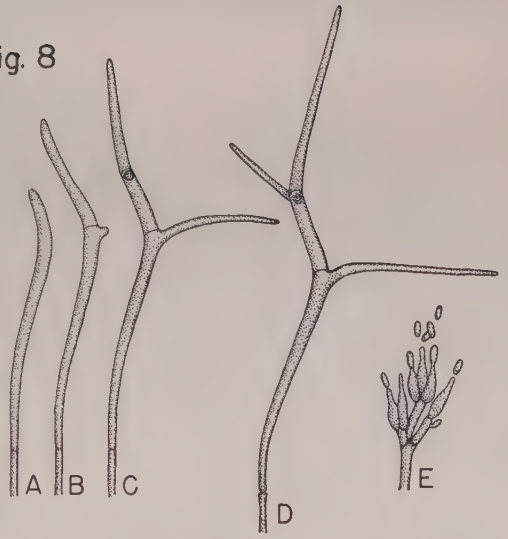


fig. 9

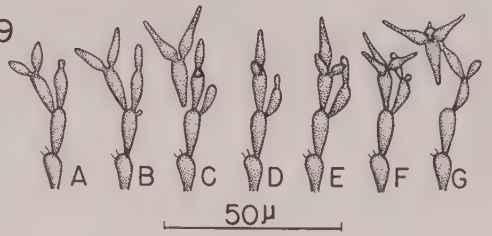


Fig. 10. A–F. *Tetrachaetum elegans* Ing., showing the development of an aleuriospore. **A.** The sporophore 10:40 A.M. **B.** The spore primordium has been formed by the cross-wall, 11:20 A.M. **C.** The spore primordium showing the origin of the new growing points 12:00 noon. **D.** 12:30 P.M. **E.** The same spore showing the formation of the separating cell, 1:30 P.M. **F.** Release of the mature aleuriospore at 4:05 P.M. From hanging-drop, pure culture. × 660.

Fig. 11. A–M. *Campylospora chaetocladia* n. sp. **A.** Mature, free-floating aleuriospores. **B–M.** Development of an aleuriospore. **B.** The aleuriophore, 11:20 A.M. **C.** The terminal swelling has been set off from the sporophore by a septum to form the spore primordium, 11:55 A.M. **D.** The "crozier" stage of the spore primordium, 1:20 P.M. **E.** The spore primordium is separated into a basal cell and a terminal cell by a cross-wall, 3:30 P.M. **F.** Upward enlargement of the basal cell and the downward enlargement of the terminal cell at 4:30 P.M. **G.** 5:25 P.M. **H.** The initiation of the four growing points that will develop into the four divergent appendages, 6:45 P.M. **I.** 8:00 P.M. **J.** 9:10 P.M. **K.** The curved appendages have begun to straighten out, 10:20 P.M. **L.** The mature aleuriospore was shed at 11:40 P.M. **M.** The initiation of a new spore primordium at the tip of the same sporophore, 1:10 A.M. From a hanging-drop culture of a fragment of decomposing maple leaf. × 660.

fig. 10
A
B
C
D
E
F

fig. 11
A
B
C
D
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F
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J
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50μ

Fig. 12. A–F. *Flagellospora curvula* Ing., showing development of the conidia. **A.** The terminal and basal phialide of the conidiophore have begun the initiation of spore primordia, 11:35 A.M. **B.** 1:50 P.M. **C.** 3:20 P.M. **D.** The mature conidium has been shed from the middle phialide, 5:15 P.M. **E.** 8:05 P.M. **F.** By 10:10 P.M. the conidium has been shed from the terminal phialide and the conidium on the basal phialide is almost mature; note that a new primordium has appeared on the terminal and middle phialides. From a hanging-drop, pure culture. × 600.

Fig. 12. G–K. *Flagellospora penicillioides* Ing. **G–J.** Shows the development of a conidium beginning at 7:55 A.M. (G) and ending at a stage near maturity of the conidium at 11:50 A.M. (J). By 12:20 the conidium had been shed and a new one had made its appearance. **K.** The terminal portion of the conidiophore from which the developmental studies were made showing the method of branching and the clusters of phialides. From a hanging-drop, pure culture. × 600.

Fig. 13. A–I. *Heliscus aquaticus* Ing. **A.** Mature, aerial conidia. **B.** A chlamydospore showing the thick wall and the oily contents. **C.** A cluster of chlamydospores. **D–I.** Developmental stages in the formation of conidia. **D.** At 10:45 A.M. **E.** 11:50 A.M. **F.** 12:40 P.M. **G.** 1:15 P.M. **H.** 2:05 P.M. **I.** The phialide on the right has produced a microconidium, 2:45 P.M. From a hanging-drop, pure culture. × 600.

Fig. 13. J–P. *Alatospora acuminata* Ing., showing development of the conidia. **J.** Early stage of the spore primordium on the phialide to the right, 5:55 P.M. **K.** 7:50 P.M. **L.** The conidium has been shed from the left phialide; curvature of the spore axis is evident on the spore primordium to the right, 9:40 P.M. **M.** 10:45 P.M. **N.** The growing points which will form the two divergent branches have appeared, 11:45 P.M. **O.** 1:15 A.M. **P.** The conidium is near maturity, 2:30 A.M. From a hanging-drop culture of the fungus growing on a decayed leaf fragment. × 600.

fig. 12

fig. 13

Fig. 14. A–K. *Lemonniera cornuta* n. sp. Stages in the development of a conidium. **A.** The mature conidium has been shed and the small spherical swelling at the tip of the phialide is the primordium of a new conidium, 2:30 P.M. **B.** The same primordium at 3:27 P.M. **C.** The spore primordium has assumed an inverted tetrahedron aspect with the four growing points already developed by 7:00 P.M. **D.** The same at 7:35 P.M. **E.** By 8:15 the growing points are short branches. **F.** 9:05 P.M. **G.** 10:30 P.M. **H.** 11:40 P.M. **I.** By 12:55 A.M. the conidium is almost mature. **J.** By 9:10 A.M. the conidium has been shed and a young spore has formed under it at the apex of the phialide. In still water the released conidium may remain for a long time at rest on top of the new conidium developing beneath it. **K.** The terminal portion of a conidiophore showing branching. From a hanging-drop, pure culture. × 740.

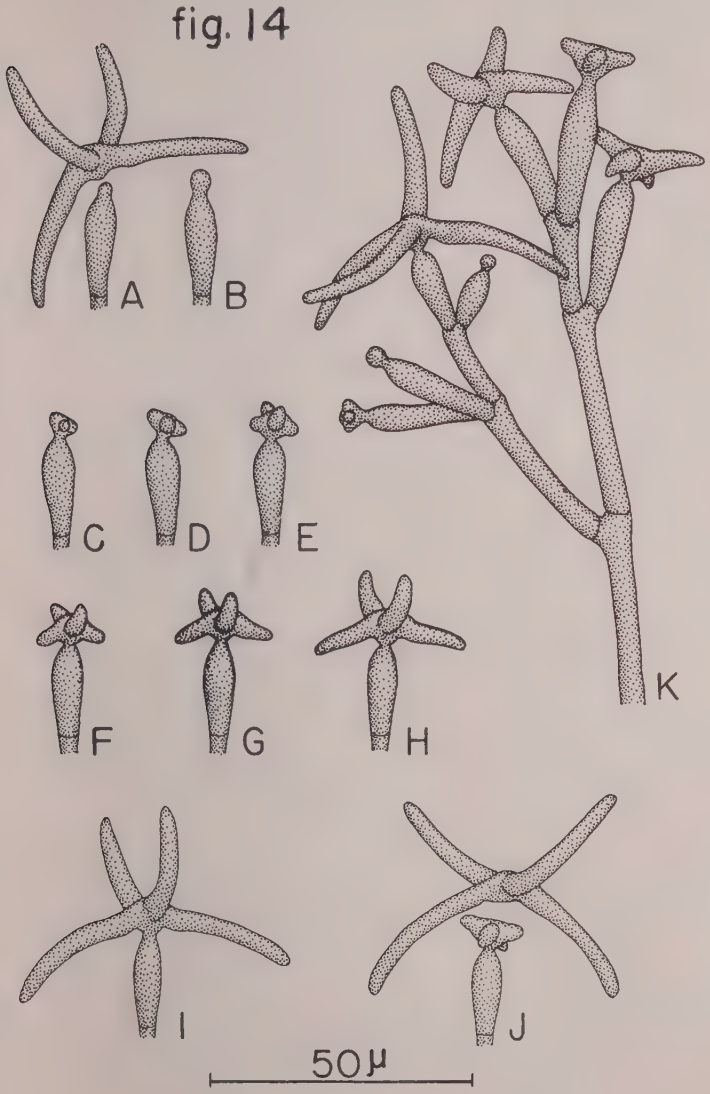
fig. 14
A
B
C
D
E
F
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50μ

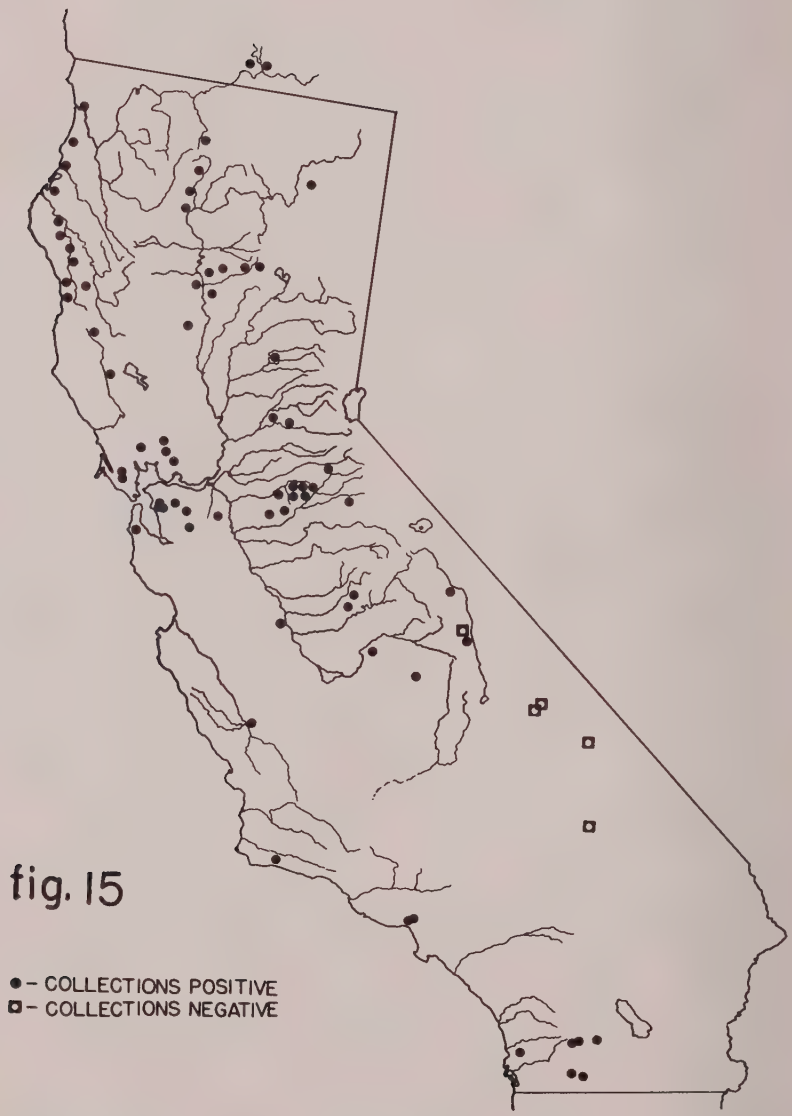

Fig. 15. An outline map of California showing the principal water courses, lakes, and those areas in which collections were made for aquatic Hyphomycetes.

SPECIAL NOTICE

It is with regret that we announce that this issue, Volume 4, Number 4, brings Farlowia to a close.

Greatly increased publishing costs and other reasons make this decision necessary. If at any time Farlowia is resumed the present subscribers will be notified.

We wish to thank all those who helped in contributing to this magazine during the twelve years of its existence.

Very sincerely,

EDGAR V. SEELER, JR., *Editor*

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July 1, 1955